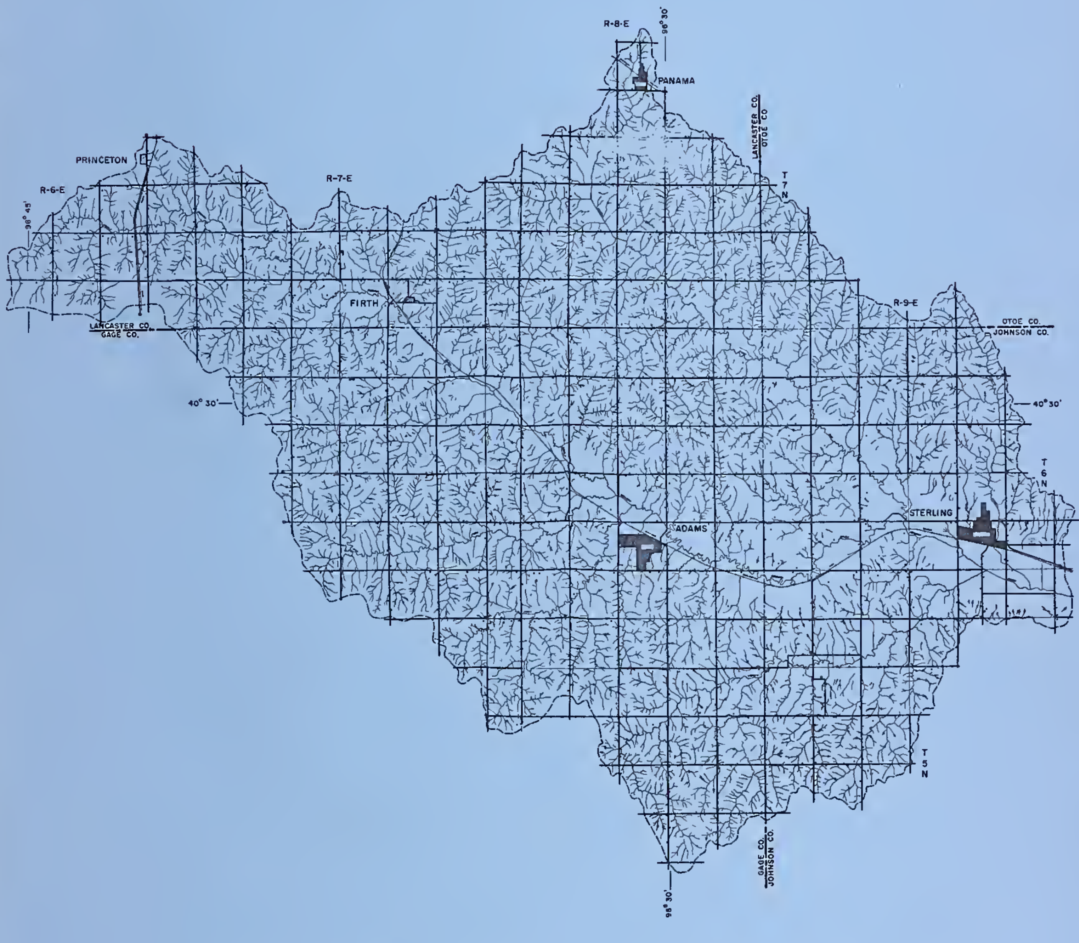
WATERSHED WORK PLAN

FOR

WATERSHED PROTECTION

AND

FLOOD PREVENTION



UPPER BIG NEMAHA WATERSHED

JOHNSON, OTOE, LANCASTER and GAGE COUNTIES, NEBRASKA

FEBRUARY, 1965

USDA-SCS-LINCOLN, NEBR. 1965

WATERSHED WORK PLAN

UPPER BIG NEMAHA WATERSHED

Johnson, Otoe, Lancaster, and Gage Counties, Nebraska

Prepared Under the Authority of the Watershed Protection and Flood Prevention Act. (Public Law 566, 83d Congress, 68 Stat. 666) as amended.

Prepared By: Gage County Soil and Water Conservation District; Johnson County Soil and Water Conservation District; Lancaster Soil and Water Conservation District; Otoe Soil and Water Conservation District; and Upper Big Nemaha Watershed Conservancy District

With Assistance By:

U. S. Department of Agriculture, Soil Conservation Service

U. S. Department of Agriculture, Forest Service

State of Nebraska Soil and Water Conservation Commission

February, 1965

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SUMMARY OF PLAN

Upper Big Nemaha Watershed is 114,980 acres in size and is located in Johnson, Gage, Lancaster and Otoe Counties, Nebraska, approximately 30 miles south of Lincoln, Nebraska.

The sponsors are the Johnson County, Gage County, Lancaster and Otoe Soil and Water Conservation Districts and the Upper Big Nemaha Watershed Conservancy District. The Soil Conservation Service and the Forest Service gave technical assistance in preparing the plan. The State of Nebraska Soil and Water Conservation Commission furnished funds and personnel to assist in the collection and processing of field data.

Watershed problems consist of both floodwater and grade stabilization. The project will provide the following protection: Average annual floodwater damage to crops and pastures will be reduced 67 percent; 6,920 acres of upland will benefit by base grade stabilization. Conservation treatment will be established on 34,015 acres of cropland; 12,400 acres of rangeland; 11,046 acres of pastureland; 3,288 acres of other land and 800 acres of woodland.

Average annual reduction in damages to crops and pastures will amount to $127,160.

Structural works of improvement will consist of 59 grade stabilization structures and 38 floodwater retarding structures to be installed over an eight-year period.

Estimated cost of installing the project is $6,376,920. Public Law 566 cost share is $3,415,850, of which $411,050 is for technical assistance to speed-up the establishment of land treatment measures and $3,004,800 is for installing structural measures. The cost share provided by local interests is $2,961,070. The value of land treatment applied to date is $2,056,400. Farmers will establish additional land treatment during the installation of the project at a cost of $2,359,250, for a total of $4,415,650. Immediately after the local people filed their application with the State of Nebraska Soil and Water Conservation Commission in March, 1959 they began accelerating the application of land treatment. Funds provided for technical assistance for land treatment under current Soil Conservation Service programs amount to $91,020 during the installation period.

The sponsors will operate and maintain structural measures after installation at an average cost of $6,790 annually. Funds, materials, and labor for these purposes will be furnished by the watershed conservancy district, as provided for by Nebraska law.

Estimated average annual benefits from the installation of structural measures are \$245,950. Average annual equivalent costs of structural measures are \$146,610. The ratio of benefit to cost is 1.7 to 1.

DESCRIPTION OF THE WATERSHED

Physical Data

Upper Big Nemaha Watershed contains 179.65 square miles or 114,980 acres and has 28,745 acres in Johnson County; 3,450 acres in Otoe County; 31,045 acres in Lancaster County; and 51,740 acres in Gage County. The Big Nemaha River begins in the southeast part of Lancaster County, the southwest part of Otoe County, the northeast part of Gage County, and the northwest part of Johnson County and flows southeasterly entering the Missouri River in the southeast corner of Richardson County, Nebraska just north of the Kansas-Nebraska state line. The watershed is about 12 miles wide and 22 miles long. It consists of the uppermost reaches of the Big Nemaha River including Middle Branch, North Fork, Hooker, Jakes and Shaw Creeks.

Topography varies from nearly level to steep. Uplands are predominantly gently to moderately sloping. Surface elevations range from about 1,140 feet at the lower end of the watershed to 1,440 feet on the divide. The total relief is 300 feet. The average grade of the main channel is seven feet per mile. Portions of main tributaries and the Nemaha River itself have been straightened causing the channels to entrench and in places they are quite deep.

Predominant upland soils series are Adair, Burchard, Crete, Geary, Morrill, Pawnee, Shelby and Wymore. Valley and floodplain soils are alluvial land and Hobbs, Colo, Rokeby, and Muir soils series.

About 13 percent of the area is in tame and native grass and is rated as a fair hydrologic condition. Principal crops are corn, milo, wheat, and alfalfa.

Predominant tree species found are ash, elm, oak, walnut, hackberry, maple and cottonwood. The woodland is located mainly along the watercourses. In some areas, woodland cover extends out into wider bottoms but often it is rather narrow. These sites are particularly adopted to walnut growing. The stands are usually fully stocked, but tree quality and stand composition are poor. Stringers of willow growing in drainage ways are very common throughout the watershed. Most of the stringers are too narrow to be included as woodland type vegetation.

Most of the precipitation is from high intensity and short duration thunderstorms. Average annual precipitation at Syracuse, twenty miles northeast of the watershed, is 29.30 inches. Maximum recorded annual precipitation was 42.03 inches in 1950. The minimum was 18.44 inches in 1953. Maximum temperature recorded was 116° and the minimum was -33°. The average frost-free period is April 29 to October 8. Average length of the growing season is 162 days, with 70 percent of the rainfall occurring during that time.

An adequate supply of water is available for domestic use. Ample irrigation water is found in parts of the watershed.

Many species of wildlife occur in the project area. The watershed is located in the heart of the prime bobwhite quail habitat in Nebraska. This upland game bird provides a very substantial amount of hunting for local and non-local hunters.

Moderate numbers of pheasants occur in the watershed area also, and are taken by hunters. However, the best pheasant habitat and the highest pheasant densities are located several counties northwest of the project area.

White-tailed deer are found in the area but not in significant numbers. Downstream in the lower reaches of the Big Nemaha River, where heavier bottomland cover is available, the white-tails are more abundant.

Squirrels and cottontail rabbits abound in the project area and furnish a great deal of sport for some small game hunters.

Waterfowl make occasional use of the streams in the project area during periods of migration.

The diversity of vegetation types in the project area, from dense woodland to row-cropped fields, maintains the large variety of non-game, or songbirds, which frequent the region. The esthetic value of non-game birds and mammals is a facet of the wildlife resources of an area which will assume increasing importance in the years ahead.

Economic Data

Economy of the watershed is based on dryland agriculture, with some interest in irrigation. Development of irrigated land took place over a very short period and has stabilized. Interest in irrigation is not expected to increase in the near future. Estimated acreage and percentage distribution of present and future land use is as follows:

Land Use	Present		Future with Project	
	Acres	Percent	Acres	Percent
Cropland	93,480	81.3	84,484	73.5
Pastureland	4,550	4.0	6,584	5.7
Rangeland	10,625	9.2	12,693	11.0
Woodland 1/	910	.8	1,054	.9
Other	5,415	4.7	10,165	8.9
Total	114,980	100.0	114,980	100.0

1/ There are no lands under the jurisdiction of the Forest Service in this watershed.

Woodland sites are rated "very high" potential in terms of growth rates for high value trees such as walnut. Maple and cottonwood on the wettest sites will also produce a good economic return. Little management has been practiced in the past which has resulted in all woodlands being dominated by low grade trees with little present or potential value.

Woodland owners have a very limited knowledge in timber production. This condition, when corrected, will improve income and add to watershed protection. Income should be entirely satisfactory on these fertile woodland areas by following proper production methods.

The majority of farming operations are a cash-grain cattle-feeding enterprise. Approximately 40 percent of the feed grains are consumed by on-farm livestock. Grain markets are located at Princeton, Firth, Adams, Panama and Sterling. Markets for livestock are at Beatrice, Syracuse, Lincoln, Tecumseh, and Omaha, Nebraska and St. Joseph and Kansas City, Missouri.

The populations of the three villages located within the watershed have changed from 1950 to 1960 as follows: Adams, a decrease from 457 to 387; Firth, an increase from 245 to 277 and Sterling, a decrease from 547 to 471.

An estimated 3,000 people live in the watershed. Federal Highway No. 77 crosses the upper portion of the watershed. State Highways No. 41, 43, 341 and 577 pass through the area. County and township roads bound almost every section. The area is served by the Chicago, Burlington and Quincy, Union Pacific and Missouri Pacific Railroads.

There are approximately 475 farming units, wholly or partially within the watershed. They vary in size from 40 to 700 acres. The average unit contains 250 acres. Estimated value of a farm unit, including buildings, is $37,500.

The national trend of fewer but larger and more efficient family farms is also prevalent in the Upper Big Nemaha Watershed. The census of agriculture for 1954 to 1959 show that in the four counties involved the number of farms has decreased from 7,500 to 6,829, but the average size of these farms has increased from 222 acres to 241 acres.

The Soil and Water Conservation Districts that make up this watershed were formed as follows: Johnson County, February, 1943; Gage County, April, 1943; Lancaster, May, 1941; and Otoe, May, 1941.

WATERSHED PROBLEMS

Floodwater Damage

Floodwater damages to crops, pastures, other agricultural properties, roads and bridges are the principal watershed problems. These damages are generally associated with storms which occur on the average of three times per year. These flood-producing storms occur most frequently during June and early July when crops are most susceptible to damage. Approximately 9,880 acres of crops are subject to inundation by a 100-year frequency storm event. About 7,370 acres are flooded by the four-year frequency storm. This land is valued at $250 per acre.

Agricultural properties damaged by flood water include fences, farm buildings, and machinery.

There are 11.5 miles of state, county, and township roads and 69 bridges and culverts subject to damage. Flood damage to roads consists of removal of surface materials and erosion of fills. Losses to bridges reflect an increased maintenance and replacement cost that is directly attributed to flood waters.

Approximately 7.1 miles of railroad track are subject to some degree of floodwater damage from the 100-year frequency storm event. Losses to this facility consist of fill and ballast removal, track damage, interruption of service and/or rerouting of scheduled trains.

Present floodwater damages from the large frequency storms occur to the low-lying areas within the Villages of Adams and Sterling. These damages consist of losses to residences and businesses and increased maintenance of village streets and utilities. Future expansion of a significant nature is not expected to occur in these villages.

Flood damage inventories made by local people show approximately 8,860 acres of crop and pasture lands flooded by the storm of May, 1950. The order by magnitude of damages are (1) crop and pasture; (2) roads and bridges; (3) agricultural properties, such as fences, farm machinery, livestock and buildings; and (4) land damage from floodplain scour and sediment deposition. The sponsors' estimate of damages resulting from this storm was $1,132,000. This flood was determined to be about a 20-year frequency event.

There is a need for some land use adjustment from cropland to rangeland on land capability class VI. With ASCS-ACP cost-sharing the landowners and operators can install needed land treatment measures.

Woodland Problems

Grazing is practiced in many of the woodlands. A vigorous, well-managed woodland has a greater capacity to retard erosion and reduce runoff than other vegetative types. Grazing reduces the capacity for rapid intake of water into the soil. Soil compaction and loss of humus and litter are a result of heavy grazing.

When unwanted trees, brush, or weeds are to be killed by spraying, care should be exercised. Valuable timber production is often killed or seriously damaged.

Damage by floating logs to structures and bridges will be less when proper woodland management is practiced.

Encouraging desirable reproduction and discouraging weed species growth in all woodlands is needed. Income potential needs improving to satisfy landowners.

Sediment Damage

Flooding deposits infertile sediment on portions of the floodplain and in roadside ditches increasing maintenance cost. Under present conditions, approximately 260,000 tons of sediment is delivered at the lower end of the Upper Big Nemaha Watershed annually.

Erosion Damage

Sheet erosion accounts for approximately 65 percent of the sediment movement within the watershed. Gully erosion is responsible for 25 percent, with roadside erosion 10 percent. The absence of stable base grades in 104 areas has prevented the installation and/or maintenance of land treatment measures. Most of these areas are seriously gullied to considerable depth with active overfalls. Some

Areas are so deeply gullied that they will require mechanical measures to reduce channel depth before vegetative outlets can be installed or maintained. In these cases landowners are being denied benefits that would accrue from such measures as terraces, contour farming, and waterway development. Streambank erosion is confined primarily to the outside banks of the sharper meanders.

Floodplain scour damages, especially in the form of scour channels, have resulted in reduced production potential of 10 to 80 percent on a total of 474 acres.

PROJECTS OF OTHER AGENCIES

The U. S. Army Corps of Engineers and the Bureau of Reclamation, Department of Interior, are investigating the need for improvements for flood control, water conservation, irrigation, recreation and allied purposes in the Nemaha River Basin. The Upper Big Nemaha watershed project will have a favorable effect on the basin.

BASIS FOR PROJECT FORMULATION

Objectives of the sponsoring local organizations are to install a project which will:

1. Reduce floodwater damage to farmsteads, cropland, pasture, fences, roads and bridges.
2. Stabilize gradients for the installation and/or maintenance of land treatment measures where necessary.
3. Reduce sediment damage to bottomland, roads, drainage ways, and reservoirs.
4. Reduce land damage by sheet and gully erosion.

The objective of the land treatment phase is to use each acre within its capabilities and to treat it according to its needs.

Official action was taken by the watershed board of directors accepting the level of protection offered by a system of land treatment, 38 floodwater retarding structures and 59 grade stabilization structures.

Topography limits the number of sites available for floodwater control. Sites were selected that would reservoir as much drainage area as possible and affect the least number of roads, farmsteads, utilities, and cropland.

A greater reduction in average annual floodwater damages would require moving structures downstream or adding structures with unfavorable benefit-cost ratios. These structures would affect roads, farmsteads or utilities.

All the information on land treatment measures shown on Tables 1 and 1A was obtained from the sponsors assisted by the local Soil Conservation Service technicians and the State Extension Forester.

WORKS OF IMPROVEMENT TO BE INSTALLED

The project consists of conservation treatment to 34,015 acres of cropland, 12,400 acres of rangeland; 11,046 acres of pastureland; 800 acres of woodland; 455 acres

of other land; and the installation of 38 floodwater retarding structures and 59 grade stabilization structures. (Table 1 and Project Map, Figure 5).

Land Treatment Measures

A minimum of seventy-five percent of the required land treatment measures above structures will be installed prior to or concurrent with construction of structural measures.

Soil surveys are substantially complete.

An alternative land use for cropland, land capability classes III and IV would be conversion to rangeland or pastureland.

Since making application under Public Law 566 local people have accelerated the installation of land treatment. Applied to date land treatment is included in Table 1A. Also included on this table is the amount of land treatment to be applied after the installation of the project. All land treatment measures will be maintained by the farmers.

Conservation measures for nonirrigated cropland include conservation cropping systems, contour farming, drainage mains or laterals, grassed waterways, diversions, gradient terraces, field border plantings, grade stabilization structures and tile drains.

Conservation Cropping System: Growing crops in combination with needed cultural and management measures. Cropping systems include the use of rotations that contain grasses and legumes, as well as sequences in which the desired benefits are achieved without the use of such crops. This practice is used to meet the needs of the soil for improvement or maintenance of good physical condition; protect the soil during critical periods when erosion usually occurs; and in controlling weeds, insects and diseases; and fulfill the needs and desires of the farmers for an economic return.

Contour Farming: Conducting farming operations on sloping, cultivated land in such a way that plowing, land preparation, planting, and cultivation are done on the contour.

Diversion: A channel with a supporting ridge on the lower side constructed across the slope used to intercept runoff and divert it to a safe outlet.

Drainage Main and Lateral: An open drainage ditch constructed to a designed size and grade.

Grassed Waterway or Outlet: A natural or constructed waterway or outlet shaped or graded and established in suitable vegetation as needed for the safe disposal of runoff from a field, diversion, terrace, or other structure. Grassed waterways facilitate the use of other conservation practices such as contour farming, terracing, and other farming operations.

Terrace, Gradient: An earth embankment or a ridge and channel constructed across the slope at a suitable spacing and with an acceptable grade. Gradient terraces are constructed to reduce erosion damage by intercepting surface runoff and conducting it to a stable outlet at a non-erosive velocity, or to retard runoff to conserve water.

Field Border Planting: Establishing a border or strip of perennial vegetation at the edge of a field.

Grade Stabilization Structure: A structure such as a drop inlet, chute, or drop installed in a watercourse to stabilize the grade. Usually requires special design, and may include floodwater detention capacity.

Tile Drain: A covered drain, such as tile or pipe, of suitable size installed beneath the surface with a planned grade and depth.

Nonirrigated cropland will be considered to meet the requirements of adequate treatment when these land treatment measures are installed:

1. Land Capability Classes I and IIs_2 (level to nearly level)

    a. Conservation cropping systems with few restrictions.

2. Land Capability Class II (slightly sloping)

    a. Grassed waterways, terraces, contour farming, and a conservation cropping system with few and moderate restrictions.

3. Land Capability Classes III and IV (moderately sloping)

    a. Grassed waterways, terraces, contour farming, and a conservation cropping system with moderate restrictions.

4. Land Capability Classes VI and VII (steeply sloping)

    a. Grade stabilization structure.

Conservation measures for irrigated cropland are conservation cropping systems, irrigation field ditches, irrigation land leveling, and irrigation water management.

Irrigation Field Ditch: A permanent irrigation ditch constructed to convey water from the source of supply to a field or fields within the farm distribution system.

Irrigation Land Leveling: Reshaping the surface of land to be irrigated to planned grades.

Irrigation Water Management: The use and management of irrigation water, where the quantity of water used for each irrigation is determined by the moisture-holding capacity of the soil and the need of the crop, where the water is applied at a rate and in such a manner that the crops can use it efficiently and significant erosion does not occur.

Irrigated cropland will be considered to meet the requirements of adequate treatment when these land treatment measures are installed:

1. Land Capability Classes I and II (level to slightly sloping)

    a. Conservation cropping system with few restrictions and irrigation water management.

Conservation measures for rangeland include farm ponds, range seeding, and range proper use.

Farm Pond: A water impoundment made by constructing a dam or embankment and used to water livestock and provide for improved distribution of grazing.

Range Seeding: Establishing adapted native grasses.

Range Proper Use: Grazing rangelands at an intensity which will maintain adequate cover for soil protection and maintain or improve the quantity and the quality of desirable vegetation. Graze about half and leave about half of the annual growth.

Rangeland will be considered to meet the requirements of adequate treatment when these land treatment measures are installed:

1. All Land Capability Classes.

    a. Range proper use.

    b. Range seeding and range proper use.

    c. Farm ponds and range proper use.

Conservation measures for pastureland include farm ponds, pasture planting, and pasture proper use.

Pasture Planting: Establishing adapted species of domesticated perennial, biennial, or reseeding forage plants on new pastureland converted from other uses.

Pasture Proper Use: Grazing pastureland at a rate that will maintain grasses and legumes of high quality by adjusting the stocking rates or season of use to favor maximum growth and survival.

Pastureland will be considered to meet the requirements of adequate treatment when these land treatment measures are installed:

1. Land Capability Classes I through IV.

    a. Pasture proper use.

    b. Pasture planting and pasture proper use.

    c. Farm ponds and pasture proper use.

The conservation measure for other land is critical area planting.

Critical Area Planting: Stabilizing silt-producing and severely eroded areas by establishing vegetative cover.

Other land will be considered to meet the requirements of adequate treatment when this land treatment measure is installed:

1. All Land Capability Classes.

    a. Critical area planting.

The conservation measures for woodland are forest protection, improved forestry practices and forestation.

Forest Protection: Woodland grazing should be limited so as to cause minimum damage to the hydrologic condition of the site. Fencing to exclude livestock will be needed to adequately protect some of these sites.

Improved Forestry Practices: Included are sustained yield and cultural practices of proper harvest, release from undesirable competition, improving stand composition, and pruning of certain crop trees.

Forestation: Tree planting to bring thinly stocked woodlands to a proper level of production and watershed protection and to change composition to the desired tree species.

Woodland will be considered to meet the requirements of adequate treatment when these land treatment measures are installed:

1. All Land Capability Classes.

    a. Forest protection.

    b. Improved forestry practices.

    c. Forestation.

Consideration, within the limits of project authorization, will be given to design and construction of practices which will alleviate the mosquito problem associated with the project development.

Structural Measures

Thirty-eight floodwater retarding structures and 59 grade stabilization structures are needed to provide the agreed level of protection. The estimated cost of installing the floodwater retarding structures is $2,692,700 and the grade stabilization structures is $821,200. (Table 2).

Floodwater retarding structures will control runoff from 56 percent of the drainage area. They will have storage capacity to detain runoff from a four percent chance storm event without operation of the emergency spillway. They

will provide floodwater detention storage of 16,285 acre feet. (Figure 1 and Table 3).

Provisions are made in the floodwater retarding structures for 50-year sediment-storage capacity of 7,934 acre feet. The crest of the risers will be at the sediment pool elevation at the dam. Principal spillways will be specially designed, closed conduits through the embankments to discharge the detention volume in 13 days or less. Embankments will be rolled earth and seeded to perennial grasses. Emergency spillways will be earthen, seeded to perennial grasses, and designed to carry flows at safe velocities. A general plan and cross section of a typical retarding structure is shown in Figure 1.

Grade stabilization structures G-5, J-22, J-24 and J-34 (Table 2) will be altered to provide top widths of 20 to 26 feet for their use as public roadways.

Land stabilization problem areas require base grade stabilization. These will be controlled by steel drop spillway or drop inlets; each having a life expectancy of 50 years. Drop spillways will be designed for a 25-year frequency storm. A general plan and cross section of a typical drop inlet grade stabilization structure is shown in Figure 2 and for a typical drop spillway grade stabilization structure see Figures 3 and 4.

EXPLANATION OF INSTALLATION COSTS

Total project costs include cost of installing structural measures for waterflow control, land stabilization and land treatment measures for watershed protection. (Table 1).

Funds estimated to be needed by years for project installation are:

	Public Law 566	Other
First Fiscal Year	$ 481,280	$ 357,200
Second Fiscal Year	385,780	371,300
Third Fiscal Year	425,380	373,300
Fourth Fiscal Year	460,680	378,000
Fifth Fiscal Year	363,380	347,200
Sixth Fiscal Year	441,080	354,800
Seventh Fiscal Year	486,780	400,700
Eighth Fiscal Year	371,490	378,570
Total Project Cost	$3,415,850	$2,961,070

Land Treatment Measures

Estimated project installation costs for land treatment are $2,359,250. The cost, as experienced by landowners and operators in applying land treatment measures, was used to estimate future installation costs. It includes the value of cost-sharing assistance to be received under other programs.

Technical assistance costs include the value of time, travel, and other expenditures in developing basic conservation plans, laying out practices, and supervising installation of these measures.

Structural Measures

Cost of installing structural measures includes construction, installation services, administration of contracts, and land, easements, and rights-of-way.

Unit values for estimating construction costs are similar to 1964 contract costs. A ten percent contingency allowance is included. Construction cost includes funds for vegetating and fencing embankments and emergency spillways.

Costs for installation services are based on current costs of constructing similar structures. Funds are provided for investigation of borrow for foundation conditions and embankment. Values of land, easements, and rights-of-way include the cost of construction permits and sponsors' estimate of cost to them for easements and flowage rights for structural measures.

Non-project construction costs will consist of increased fill and additional length of pipe to permit structures G-5, J-22, J-24 and J-34 (Table 2) to be used as roadways.

EFFECTS OF WORKS OF IMPROVEMENT

Land treatment measures will benefit all farms within the watershed by preventing soil erosion, retarding runoff and providing favorable effects downstream. Water-flow control measures will provide reductions in floodwater damages to 220 farms that lie below these measures. Grade stabilization structures will provide reduction in erosion damage to 206 beneficiaries.

Sediment production will be reduced 74 percent as the result of additional land treatment, improved cropping systems, expected changes in land use, and the installation of structural measures.

Installation of base grade stabilization structures and the associated land treatment measures will eliminate land voiding to 293 acres and land depreciation to 6,627 acres of good agricultural land.

Floodwater damages under present conditions occur over an area of 9,880 acres. The project will reduce average annual crop and pasture damages by 67 percent. Land treatment measures account for 13 percent of this reduction. The project will also reduce the area inundated by the four-year frequency storm event from 7,340 acres to 4,175 acres or by 43 percent.

Abatement of hazards to fences, farm buildings, and driveways will enable farmers to repair or replace these properties at less expense.

Benefits will accrue to 11.5 miles of roads and 69 bridges. Damages to these facilities will be reduced 74 percent.

The project will also reduce the average annual railroad damage by 95 percent.

The Villages of Adams and Sterling will receive protection from the three-year and two-year frequency storms respectively. Average annual urban damages will be reduced 79 percent by the project.

Indirect benefits occur as a reduction in past damages resulting from interruption of transportation, communications, and public utilities.

Reduction in frequencies of floods will permit conversion of small, isolated areas to higher valued use. This will occur only in areas adjacent to the main channel where these reductions are significant.

Loss of wildlife habitat due to location of structures and future inundation will have some detrimental effects on existing wildlife species. A number of the areas to be inundated contain existing native timber with an understory of herbaceous and shrubby cover. This cover is of value as habitat to quail, squirrels, rabbits, pheasants, and other native wildlife species. Loss of these areas due to inundation and clearing will reduce wildlife habitat in the watershed district but not to such an extent that specific project features to mitigate these losses are considered necessary.

Benefits will accrue to fish and wildlife resources through creation of new aquatic habitat and may provide income-producing, on-farm recreational enterprises. As the impoundments age and mature the upper reaches will develop silt beds which will have value for migratory waterfowl. It is expected that the impoundments will attract waterfowl to the area. Stabilization of water fluctuation and flow in the middle branch of the Big Nemaha River and its tributaries will improve conditions for fishery resources.

Secondary benefits stemming from the project will accrue within its immediate zone of influence. These benefits are from the transporting, processing, and marketing of those goods and services that produce primary benefits and from the supplying of additional materials.

The project will help stabilize the agricultural economy of the watershed due to increased net income of farmers. Fishing will be improved by eliminating heavy floodwater flows that now occur periodically.

PROJECT BENEFITS

Flood prevention benefits from the project are estimated at $289,280. The following table lists monetary benefits that are derived from significant items:

Items	Average Annual Benefits
Agricultural	
Crop and Pasture	$127,160
Other Agricultural	19,080
Nonagricultural	
Road and Bridge	40,260
Railroad	1,580
Urban	5,450
Erosion	
Floodplain Scour	5,330
Gullies	46,370
Sediment	
Sediment Deposition	500
Indirect	24,680
Changed Land Use	2,400
More Intensive Use	130
Secondary	16,340
Total Average Annual Benefits	$289,280

Total application of additional land treatment measures will have a major effect in reducing sediment production and will provide $43,330 annually in flood prevention benefits. The structural measures account for $245,950.

Secondary benefits from a national viewpoint were not considered pertinent to the economic evaluation.

COMPARISON OF BENEFITS AND COSTS

Estimated average annual cost of the structural measures is $146,610. These structural measures, when operational, are expected to produce average annual primary benefits of $229,610. The ratio of primary benefits to costs is 1.6 to 1.

Total average annual structural benefits are expected to be $245,950. The ratio of these benefits to costs is 1.7 to 1, as shown in Table 6.

PROJECT INSTALLATION

The work plan proposes an eight-year period for installation of the project.

Land Treatment Measures

As structural locations are presented to the local sponsors a determination is made as to the amount of land treatment already applied. The land treatment to be applied during and after the project is discussed between the local sponsors and technicians and a program for applying the minimum of 75 percent land treatment above structures is scheduled. Small kitchen meetings will be used to help

carry out the program. These are meetings where a landowner or operator invites three or four of his neighbors into his home along with a member of the local Soil Conservation Service office, Soil and Water Conservation District Board, and Watershed Conservancy District Board so the technicians and local sponsors can discuss the land treatment for their farms.

Land treatment measures will be established on the land by farm owners and operators in cooperation with the Johnson County, Gage County, Lancaster and Otoe Soil and Water Conservation Districts.

Technical assistance will be provided by technicians of the Soil Conservation Service and the State Extension Forester in cooperation with the U. S. Forest Service.

The Extension Service will assist with the educational phase of the project. Local farm meetings, tours, radio and press releases will be used to inform landowners and operators and the general public about the project.

The Farmers Home Administration will encourage borrowers to cooperate in project activities and will provide information on loans available for conservation work.

The governing bodies of the Johnson County, Gage County, Lancaster and Otoe Soil and Water Conservation Districts will work with the Johnson, Gage, Lancaster and Otoe County Agricultural Stabilization and Conservation Committees to provide cost-sharing funds to accelerate application of conservation practices. Emphasis will be given to helping farmers install land treatment which will be effective in attaining project objectives.

The Board of Supervisors of the Johnson County, Gage County, Lancaster and Otoe Soil and Water Conservation Districts and directors of the conservancy district will schedule meetings and arrange for individual contact to encourage landowners and operators to adopt and apply soil and water conservation measures. They will confer with and enlist the assistance of Johnson, Gage, Lancaster and Otoe county and township officials in establishing conservation measures on roadways.

Structural Measures for Flood Prevention

The Upper Big Nemaha Watershed Conservancy District, organized under Nebraska statutes, will be the contracting agency for the construction of structural measures. They have been authorized by the other sponsoring organizations to act for them in performing this duty. This will include appointing a contracting officer to perform the contracting duties for the board of directors.

The Conservancy District will acquire necessary land, easements, and rights-of-way for works of improvement. All powers granted them by the state will be used, if necessary, to achieve project objectives. This includes the right of eminent domain. The directors have contacted the owners of property upon which works of improvement are to be installed. Most have agreed that an amicable settlement can be reached.

A working agreement between the Johnson and Gage County Boards of Commissioners and the Conservancy District will be developed to provide for non-project

construction costs and rights-of-way that may be required for installing and maintaining those works of improvement that are altered for roadway use.

Technicians of the Soil Conservation Service will assist in planning, design, preparation of specifications, supervision of construction, preparation of contract estimates, making final inspections, execution of certificates of completion, and performing other related duties for the establishment of the planned measures for flood prevention.

The Nebraska Department of Health will provide technical assistance on the prevention and control of mosquitoes upon request by sponsoring local organizations.

Sponsoring local organizations have developed a plan for application of land treatment measures and securing land, easements, and rights-of-way for project improvements. This plan lists priorities for installation of structural works. It sets the approximate date easements for structural sites are to be recorded and the required land treatment established. The following table summarizes their plan.

Year	Record easements for and meet minimum requirements for establishment of land treatment above
First Year	Five floodwater retarding structures and eight grade stabilization structures.
Second Year	Five floodwater retarding structures and eight grade stabilization structures.
Third Year	Five floodwater retarding structures and eight grade stabilization structures.
Fourth Year	Five floodwater retarding structures and seven grade stabilization structures.
Fifth Year	Five floodwater retarding structures and seven grade stabilization structures.
Sixth Year	Five floodwater retarding structures and seven grade stabilization structures.
Seventh Year	Four floodwater retarding structures and seven grade stabilization structures.
Eighth Year	Four floodwater retarding structures and seven grade stabilization structures.

FINANCING PROJECT INSTALLATION

Cost of installing the project is $6,376,920. The Federal Government, under authority of the Watershed Protection and Flood Prevention Act, Public Law 566, as amended, will provide $3,415,850. Local interests, using other authorities and private funds, will provide $2,961,070. Availability of financial and other assistance to be furnished by the Soil Conservation Service under Public Law 566 and other authorities depends upon appropriations made for these purposes.

Farmers cooperating with the Johnson County, Gage County, Lancaster and Otoe Soil and Water Conservation District and the Extension Forester will establish

the land treatment as shown in Table 1. Estimated cost is $2,359,250. Cost-sharing assistance is available under the Agricultural Conservation Program to assist in applying these practices.

Cost of technical assistance during installation of the project is $503,770. Of this, $411,050 P.L. 566 funds are needed to speed-up application of land treatment measures. The Soil Conservation Service will furnish technical assistance under other programs valued at $91,020.

About 356 man-days of technical assistance valued at $11,380 were furnished in fiscal year 1964 under current programs. It is anticipated that this will continue through the installation period. The State of Nebraska Soil and Water Conservation Commission and the Johnson County, Gage County, Lancaster and Otoe Soil and Water Conservation Districts provided part of this assistance in the past.

The estimated cost of forestry land treatment is (1) Forest Protection, $1000; (2) Forestation, $1500; and (3) Improved Forestry Practices, $4500. Individual landowners and funds from other Federal programs, such as ACP, will bear these costs of installation.

Total cost of technical forestry assistance is $3600. Estimated cost of accelerated technical forestry assistance is $2800. These costs will be borne by P.L. 566, $1900 and the State Extension Forestry Funds, $900. Going co-operative forestry programs will furnish technical assistance valued at $800.

Cost of installing structural measures is $3,513,900. Public Law 566 share is $3,004,800. Local interests will provide $509,100.

Watershed residents have organized the Upper Big Nemaha Watershed Conservancy District under Sections 2-1550 to 2-1565, R. S. Supplement 1957 of Nebraska Statutes. Among authorities provided is the right to levy ad valorem taxes on tangible property.

The Conservancy District will use its authority to finance their share of project costs. The maximum levy provided by law will produce $18,600 annually. During the past several years a portion of the maximum levy has been in effect. Funds accumulated prior to project approval will be available for installation purposes. The District will obtain easements or fee title for all structural measures. Funds for this purpose are expected to be available from tax funds as they are needed. Most land easements and rights-of-way for grade stabilization structures are expected to be donated.

The Watershed Conservancy District may obtain funds from "the small watershed control fund" administered by the State of Nebraska through the State Soil and Water Conservation Commission to assist in acquisition of necessary land, easements and rights-of-way. Funds from this source may be used to finance a significant portion of the cost of land rights. (Sections 2-1502 and 2-1503, R. S. 1943, as amended 1963 of Nebraska Statutes).

A working agreement between the Johnson and Gage County Boards of Commissioners and the Conservancy District will provide for the reimbursement to the district

for the non-project costs. This shall be a percentage of the final contract cost (see footnotes, Table 2) due the contractor as work progresses.

Local sponsoring organizations and the Soil Conservation Service will develop annual plans of work. These plans will show the work to be accomplished in an orderly manner. Requests for allocation of government funds will be based upon these plans. Signing of the Project Agreement will obligate government funds for the project. These funds will become available to the Conservancy District upon partial and/or total completion of the construction contract.

PROVISIONS FOR OPERATION AND MAINTENANCE

Land Treatment Measures

Farm owners and operators will operate and maintain land treatment measures. Representatives of the Johnson County, Gage County, Lancaster and Otoe Soil and Water Conservation Districts will encourage owners and operators to perform needed maintenance.

Technical assistance to farm owners and operators for operating and maintaining the forestry measures beyond the installation period will be provided by the State Extension Forester in cooperation with the Forest Service under continuing forestry programs.

Structural Measures

The Upper Big Nemaha Watershed Conservancy District will operate and maintain structural measures. Representatives of the Soil Conservation Service, the Johnson County, Gage County, Lancaster and Otoe Soil and Water Conservation Districts, and the Upper Big Nemaha Watershed Conservancy District will make annual inspections of all structural measures. Representatives of the sponsoring local organizations will also make an inspection after each major storm or upon the occurrence of any unusual condition that might adversely affect proper functioning of the works of improvement. Reports will be prepared covering inspections, stating maintenance and repairs needed and an agreed date when repairs will be completed. The maintenance may include such items as clearing the trash rack, cleaning debris from face of dam and shoreline, repairing eroded areas, controlling rodents, mowing, spraying, repairing fence, etc.

Funds, materials and labor for carrying out operation and maintenance work will be furnished by the watershed conservancy district and individual landowners on whose property the works of improvement are located. Average annual operation and maintenance costs are $6,790 for structural measures. (Table 4).

An agreement between the Service and the Conservancy District specifying detailed operational requirements for each structural measure will be developed and signed concurrently with the signing of the first project agreement.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COSTS

Upper Big Nemaha Watershed, Nebraska

Installation Cost Item	Unit	Number	Estimated Cost (Dollars) 1/ P.L. 566	Other	Total
Land Treatment					
Soil Conservation Service					
Cropland Treatment	Acre	34,015	-	1,876,290	1,876,290
Pastureland Treatment	Acre	11,046	-	213,010	213,010
Rangeland Treatment	Acre	12,400	-	240,200	240,200
Other Land Treatment	Acre	455	-	22,750	22,750
Technical Assistance			409,150	91,020 2/	500,170
Subtotal - SCS			409,150	2,443,270	2,852,420
Forest Service					
Woodland Treatment	Acre	800	-	7,000	7,000
Technical Assistance			1,900	1,700	3,600
Subtotal - Forest Service			1,900	8,700	10,600
TOTAL LAND TREATMENT			411,050	2,451,970	2,863,020
Structural Measures					
Construction					
Soil Conservation Service					
Floodwater Retarding Structures	Each	38	1,726,600	-	1,726,600
Grade Stabilization Structures	Each	59	537,600	-	537,600
Subtotal - Construction			2,264,200	-	2,264,200
Installation Services					
Soil Conservation Service					
Engineering Services			514,600	-	514,600
Other			226,000	-	226,000
Subtotal - Installation Services			740,600	-	740,600
Other Costs					
Land, Easements & R/W			-	487,400	487,400
Administration of Contracts			-	21,700	21,700
Subtotal - Other			-	509,100	509,100
TOTAL STRUCTURAL MEASURES			3,004,800	509,100	3,513,900
TOTAL PROJECT			3,415,850	2,961,070	6,376,920
SUMMARY					
Subtotal - Soil Conservation Service			3,413,950	2,952,370	6,366,320
Subtotal - Forest Service			1,900	8,700	10,600
TOTAL PROJECT			3,415,850	2,961,070	6,376,920

1/ Price Base 1964.
2/ Based on eight-year installation period.

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TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT

Upper Big Nemaha Watershed, Nebraska

Treatment Measure	Unit	Total Needs	Applied to Date		Apply During Project	Apply After Project
			Amount	Value 1/ (Dollars)		
Soil Conservation Service						
Conservation Cropping System	Acre	89,200	28,630	57,260	48,460	7,100
Critical Area Planting	Acre	830	72	3,600	455	200
Diversion	Feet	286,500	170,330	17,030	69,700	31,100
Drainage Mains or Laterals	Feet	113,000	2,370	190	77,440	22,200
Farm Pond	Each	80	14	22,400	46	13
Field Border Planting	Acre	480	144	4,320	202	90
Grade Stabilization Structure	Each	610	106	169,600	252	169
Grassed Waterways	Acre	6,050	2,780	834,000	2,600	670
Irrigation Field Ditches	Feet	16,000	0	0	11,200	3,200
Irrigation Land Leveling	Acre	2,700	135	10,100	898	1,120
Irrigation Water Management	Acre	3,000	0	0	900	1,400
Pasture Planting	Acre	8,000	1,560	38,900	5,160	840
Pasture Proper Use	Acre	8,000	580	580	4,450	1,920
Range Proper Use	Acre	19,420	1,185	1,180	12,760	3,670
Range Seeding	Acre	4,240	1,350	67,500	2,610	190
Terrace, Gradient	Feet	26,400,000	13,825,000	829,500	10,060,000	1,680,000
Tile Drain	Feet	1,000	0	0	800	135
Farm Plans						
Basic Plans	Each	674	260	-	210	65
Revised Plans	Each	102	-	-	80	15
Forest Service						
I. Forest Protection						
(b) Livestock Exclusion	Acre	800	10	100	400	220

Table 1A Continued

Treatment Measures	Unit	Total Needs	Applied to Date: Amount	Applied to Date: Value 1/ (Dollars)	Apply During Project	Apply After Project
III. Forest Management						
(a) Improved Forestry Practices						
1. Sustained Yield Practices						
(a) Area Harvested	Acre	300	20	140	150	60
2. Cultural Practices						
(a) Area Treated	Acre	370	-	-	150	50
(b) Stand Conversion	Acre	200	-	-	100	10
(b) Forestation						
(1) Area Planted	Acre	100	-	-	40	40
(2) Area Seeded	Acre	400	-	-	110	140
(3) Trees Planted	Number	-	-	-	8,000	-
Total		xx	xx	2,056,400	xx	xx

1/ Price Base 1964.

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TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION
Upper Big Nemaha Watershed, Nebraska
(Dollars) 1/

Structure Number	Installation Cost - P.L. 566 Funds: Construction	Instal. Services: Engineering	Instal. Services: Other	Total PL 566	Installation Cost - Other Funds: Construction	Other: Admin. of Contracts	Other: Easements & R/W	Total Other	Total Installation Cost
Floodwater Retarding Structures									
1-B	91,700	20,800	9,200	121,700				18,000	139,700
2-A	71,400	16,200	7,100	94,700				9,000	103,700
3-A	47,000	10,700	4,700	62,400				12,100	74,500
6-A	41,700	9,500	4,200	55,400				6,300	61,700
7-A	46,300	10,500	4,600	61,400				7,900	69,300
9-A	33,500	7,600	3,400	44,500				5,200	49,700
9-B	63,400	14,400	6,300	84,100				17,500	101,600
9-C	30,800	7,000	3,100	40,900				6,800	47,700
9-D	34,500	7,800	3,400	45,700				8,100	53,800
10-A	58,300	13,300	5,800	77,400				7,000	84,400
11-A	63,400	14,400	6,300	84,100				9,700	93,800
11-B	25,000	5,700	2,500	33,200				7,100	40,300
12-A	37,400	8,500	3,700	49,600				5,600	55,200
12-B	58,300	13,200	5,800	77,300				15,500	92,800
13-A	16,900	3,800	1,700	22,400				4,500	26,900
13-C	30,300	6,900	3,000	40,200				8,400	48,600
14-A	13,700	3,100	1,400	18,200				3,100	21,300
14-B	23,200	5,300	2,300	30,800				5,100	35,900
14-C	16,000	3,700	1,600	21,300				3,000	24,300
15-A	13,800	3,100	1,400	18,300				3,500	21,800
15-B	15,600	3,500	1,600	20,700				3,800	24,500
15-D	31,900	7,300	3,200	42,400				12,000	54,400
15-E	27,300	6,200	2,700	36,200				10,300	46,500
16-A	61,400	13,900	6,100	81,400				11,900	93,300
18-A	47,500	10,800	4,700	63,000				4,300	67,300
18-B	120,000	27,300	12,000	159,300				31,700	191,000
20-A	56,600	12,900	5,700	75,200				6,700	81,900
20-B	43,400	9,900	4,300	57,600				5,400	63,000
20-C	30,400	6,900	3,000	40,300				5,300	45,600
21-A	38,700	8,800	3,900	51,400				7,800	59,200
21-B	73,600	16,700	7,400	97,700				20,300	118,000
21-D	30,000	6,800	3,000	39,800				10,100	49,900

Table 2 Continued

Structure Number	Installation Cost - P.L. 566 Funds				Installation Cost - Other Funds				Total Installation Cost
		Instal. Services				Other			
	Construction	Engineering	Other	Total PL 566	Construction	Admin. of Contracts	Easements & R/W	Total Other	
Floodwater Retarding Structures									
23-B	42,400	9,600	4,200	56,200				15,400	71,600
23-C	21,600	4,900	2,200	28,700				4,100	32,800
23-D	35,600	8,100	3,600	47,300				9,700	57,000
25-C	102,000	23,200	10,200	135,400				32,400	167,800
27-C	87,000	19,800	8,700	115,500				29,800	145,300
27-D	45,000	10,200	4,500	59,700				16,900	76,600
Subtotal	1,726,600	392,300	172,500	2,291,400		15,500	385,800	401,300	2,692,700
Grade Stabilization Structures									
J-4	10,600	2,400	1,100	14,100				400	14,500
J-5	5,000	1,100	500	6,600				300	6,900
J-11	7,900	1,800	800	10,500				1,500	12,000
J-12	21,100	4,800	2,100	28,000				3,600	31,600
J-12A	10,600	2,400	1,100	14,100				2,500	16,600
J-15	6,000	1,400	600	8,000				1,200	9,200
J-15A	6,300	1,400	600	8,300				1,400	9,700
J-22	5,100	1,200	500	6,800	(900) 2/			900	7,700
J-24	6,200	1,400	600	8,200	(1,300) 2/			600	8,800
J-27	9,400	2,100	900	12,400				1,300	13,700
J-28	9,900	2,300	1,000	13,200				1,200	14,400
J-32	8,800	2,000	900	11,700				1,000	12,700
J-34	3,300	800	300	4,400	(2,000) 2/			1,200	5,600
J-36	11,800	2,700	1,200	15,700				2,500	18,200
J-37	10,200	2,300	1,000	13,500				2,900	16,400
J-40	6,100	1,400	600	8,100				1,100	9,200
J-41	24,200	5,500	2,400	32,100				5,900	38,000
J-42	12,800	2,900	1,300	17,000				2,800	19,800
J-44	12,200	2,800	1,200	16,200				2,300	18,500
J-45	5,800	1,300	600	7,700				1,500	9,200
O-1	6,500	1,500	700	8,700				1,400	10,100
G-2	13,600	3,100	1,400	18,100				3,100	21,200
G-5	6,300	1,400	600	8,300	(600) 2/			200	8,500
G-8	4,900	1,100	500	6,500				700	7,200
G-12	7,100	1,600	700	9,400				1,600	11,000

Table 2 Continued

Structure Number	Installation Cost - P.L. 566 Funds: Construction	Installation Cost - P.L. 566 Funds: Instal. Services: Engineering	Installation Cost - P.L. 566 Funds: Instal. Services: Other	Installation Cost - P.L. 566 Funds: Total PL 566	Installation Cost - Other Funds: Construction	Installation Cost - Other Funds: Other: Admin. of Contracts	Installation Cost - Other Funds: Other: Easements & R/W	Installation Cost - Other Funds: Total Other	Total Installation Cost
Grade Stabilization Structures									
G-12A	5,600	1,300	600	7,500				1,100	8,600
G-13	9,700	2,200	1,000	12,900				1,500	14,400
G-14	5,700	1,300	600	7,600				1,300	8,900
G-15	6,500	1,500	600	8,600				900	9,500
G-16	7,300	1,700	700	9,700				600	10,300
G-16A	20,500	4,700	2,000	27,200				2,700	29,900
G-18	6,400	1,500	600	8,500				700	9,200
G-18A	13,300	3,000	1,300	17,600				4,000	21,600
G-19	11,700	2,700	1,200	15,600				2,600	18,200
G-20	6,600	1,500	700	8,800				1,100	9,900
G-22	7,600	1,700	800	10,100				1,100	11,200
G-23	7,200	1,600	700	9,500				1,000	10,500
G-24	11,000	2,500	1,100	14,600				3,000	17,600
G-25	12,500	2,800	1,200	16,500				2,800	19,300
G-27	12,400	2,800	1,200	16,400				2,400	18,800
G-29	8,000	1,800	800	10,600				1,300	11,900
G-31	15,200	3,500	1,500	20,200				1,600	21,800
G-32	7,400	1,700	700	9,800				1,400	11,200
G-33	9,000	2,000	900	11,900				2,600	14,500
G-34	7,300	1,700	700	9,700				1,500	11,200
G-35	9,800	2,200	1,000	13,000				3,500	16,500
G-37	7,400	1,700	700	9,800				1,300	11,100
L-3	8,400	1,900	800	11,100				500	11,600
L-3A	4,500	1,000	500	6,000				1,800	7,800
L-4	13,900	3,200	1,400	18,500				4,600	23,100
L-5	5,400	1,200	500	7,100				1,300	8,400
L-7	7,300	1,600	700	9,600				1,700	11,300
L-8	5,100	1,200	500	6,800				1,000	7,800
L-9	6,600	1,500	700	8,800				1,900	10,700
L-10	9,100	2,100	900	12,100				2,300	14,400
L-12	8,400	1,900	800	11,100				2,700	13,800
L-15	5,800	1,300	600	7,700				1,300	9,000

Structure Number	Installation Cost - P.L. 566 Funds				Installation Cost - Other Funds				Total Installation Cost
	Construction	Instal. Services		Total PL 566	Other			Total Other	
		Engineering	Other		Construction	Admin. of Contracts	Easements & R/W		
Grade Stabilization Structures									
L-16	14,900	3,400	1,500	19,800				3,700	23,500
L-17	8,400	1,900	800	11,100				1,900	13,000
Subtotal	537,600	122,300	53,500	713,400	(4,800) 2/	6,200	101,600	107,800	821,200
Total	2,264,200	514,600	226,000	3,004,800	(4,800) 2/	21,700	487,400	509,100	3,513,900

1/ Price Base 1964.

2/ Non-project costs for altering structures to permit their use as roadways will be based on a percentage of the final contract. These percentages are as follows: G-5, 8.7%; J-22, 15.0%; J-24, 17.3%; and J-34, 37.7%.

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TABLE 3 - STRUCTURE DATA
FLOODWATER RETARDING STRUCTURES
Upper Big Nemaha Watershed, Nebraska

Item	Unit	1-B	2-A	3-A	6-A	7-A	9-A	9-B	9-C
		Structure Number							
Drainage Area	sq. mi.	4.37	2.27	3.36	1.43	1.80	0.93	3.97	1.39
Storage Capacity									
Sediment	ac. ft.	450	180	264	134	152	88	349	122
Floodwater	ac. ft.	648	346	513	227	398	159	697	228
Total	ac. ft.	1,098	526	777	361	550	247	1,046	350
Surface Area									
Sediment Pool	acre	61.0	25.0	35.0	16.7	24.2	14.3	52.0	18.5
Floodwater Pool 1/	acre	120.0	59.0	83.0	40.3	60.0	31.2	122.0	42.5
Volume of Fill	cu. yds.	96,300	76,700	80,000	63,100	78,400	59,900	93,100	52,800
Elev. Top of Dam	feet	1,244.0	1,244.0	1,238.0	1,272.5	1,303.0	1,324.0	1,339.0	1,330.5
Maximum Ht. of Dam	feet	35.0	34.0	39.6	41.5	37.0	30.5	31.0	35.0
Emergency Spillway									
Crest Elevation	feet	1,238.5	1,238.5	1,232.5	1,267.0	1,297.5	1,318.5	1,333.5	1,325.0
Bottom Width	feet	125	70	80	30	190	30	30	30
Type		Vegetated							
Percent Chance of Use		4	4	4	4	1	4	4	4
Ave. Curve No. - Cond. II		74	75	75	76	73	78	79	77
Emergency Spillway Hydrograph									
Storm Rainfall	inch	7.78	5.28	7.78	5.28	10.65	5.28	5.28	5.23
Storm Runoff	inch	4.73	2.67	4.84	2.76	7.22	2.96	3.05	2.81
Velocity of Flow (Vc)	ft./sec.	3.8	-	6.1	-	5.3	-	-	-
Discharge Rate	c.f.s.	325	-	595	-	925	-	-	-
Maximum w.s. Elevation	feet	1,239.6	-	1,234.9	-	1,299.4	-	-	-
Freeboard Hydrograph									
Storm Rainfall	inch	13.45	7.78	13.45	7.78	25.65	7.78	7.78	7.73
Storm Runoff	inch	10.00	4.84	10.14	4.96	21.69	5.20	5.30	5.03
Velocity of Flow (Vc)	ft./sec.	8.7	5.8	10.0	6.1	10.0	5.3	6.6	5.8
Discharge Rate	c.f.s.	2,820	430	2,875	238	6,400	145	315	200
Maximum w.s. Elevation	feet	1,242.9	1,240.7	1,238.0	1,269.4	1,303.0	1,320.4	1,336.3	1,327.2
Principal Spillway									
Capacity - Maximum	c.f.s.	59	29	40	18	25	12	46	17
Capacity Equivalents									
Sediment Volume	inch	1.93	1.49	1.47	1.76	1.58	1.77	1.65	1.64
Detention Volume	inch	2.78	2.86	2.86	2.97	4.13	3.19	3.29	3.07
Spillway Storage	inch	3.18	3.09	3.20	3.57	4.05	4.40	4.02	3.99
Class of Structure		a	a	a	a	c	a	a	a

1/ Crest of emergency spillway

Item	Unit	Structure Number							
		9-D	10-A	11-A	11-B	12-A	12-B	13-A	13-C
Drainage Area	sq. mi.	1.75	1.35	2.40	1.35	1.19	3.44	0.70	1.68
Storage Capacity									
Sediment	ac. ft.	142	106	151	97	120	290	52	137
Floodwater	ac. ft.	276	221	575	244	209	603	123	296
Total	ac. ft.	418	327	726	341	329	893	175	433
Surface Area									
Sediment Pool	acre	20.8	19.0	22.6	22.3	16.0	52.7	10.3	24.3
Floodwater Pool 1/	acre	54.0	43.0	74.7	47.5	34.5	106.0	29.0	56.0
Volume of Fill	cu. yds.	62,900	62,600	83,300	40,000	63,400	96,700	30,100	50,200
Elev. Top of Dam	feet	1,330.0	1,333.5	1,351.0	1,354.0	1,360.0	1,363.5	1,382.0	1,401.0
Maximum Ht. of Dam	feet	39.4	27.5	37.0	27.0	32.5	31.5	25.0	31.0
Emergency Spillway									
Crest Elevation	feet	1,324.5	1,328.0	1,345.5	1,348.5	1,354.5	1,358.0	1,376.5	1,395.5
Bottom Width	feet	30	30	350	30	30	30	30	30
Type	- Vegetated -								
Percent Chance of Use		4	4	1	4	4	4	4	4
Ave. Curve No. - Cond. II		77	77	79	78	80	79	79	79
Emergency Spillway Hydrograph									
Storm Rainfall	inch	5.23	5.23	10.60	7.73	5.23	5.23	5.23	5.23
Storm Runoff	inch	2.81	2.81	7.97	5.15	3.10	3.01	3.01	3.01
Velocity of Flow (Vc)	ft./sec.	-	-	5.0	5.3	-	-	-	-
Discharge Rate	c.f.s.	-	-	1,320	150	-	-	-	-
Maximum w.s. Elevation	feet	-	-	1,347.2	1,350.4	-	-	-	-
Freeboard Hydrograph									
Storm Rainfall	inch	7.73	7.73	25.60	13.40	7.73	7.73	7.73	7.73
Storm Runoff	inch	5.03	5.03	22.66	10.53	5.37	5.26	5.26	5.26
Velocity of Flow (Vc)	ft./sec.	6.0	5.6	10.0	9.4	6.0	6.4	4.6	5.8
Discharge Rate	c.f.s.	232	187	11,200	1,055	229	276	93	205
Maximum w.s. Elevation	feet	1,326.9	1,330.1	1,351.0	1,353.5	1,356.8	1,360.6	1,378.0	1,397.7
Principal Spillway									
Capacity - Maximum	c.f.s.	22	17	30	20	15	43	9	22
Capacity Equivalents									
Sediment Volume	inch	1.52	1.48	1.18	1.35	1.89	1.58	1.40	1.53
Detention Volume	inch	2.96	3.07	4.49	3.38	3.30	3.29	3.54	3.29
Spillway Storage	inch	3.88	4.35	3.94	4.12	3.82	3.70	5.60	4.11
Class of Structure		a	a	c	a	a	a	a	a

1/ Crest of emergency spillway.

Table 3 Continued

Item	Unit	14-A	14-B	14-C	15-A	15-B	15-D	15-E	16-A
		Structure Number							
Drainage Area	sq. mi.	0.48	0.77	0.43	0.55	0.50	2.34	1.95	2.66
Storage Capacity									
Sediment	ac. ft.	29	55	32	29	35	169	135	284
Floodwater	ac. ft.	87	140	75	103	91	431	342	418
Total	ac. ft.	116	195	107	132	126	600	477	702
Surface Area									
Sediment Pool	acre	7.1	12.0	6.8	8.7	8.6	38.5	26.5	36.5
Floodwater Pool 1/	acre	20.0	30.6	17.0	22.1	23.4	82.0	72.0	78.0
Volume of Fill	cu. yds	23,900	42,700	28,100	23,000	27,100	50,200	44,000	78,400
Elev. Top of Dam	feet	1,398.0	1,399.5	1,408.0	1,403.5	1,420.0	1,427.5	1,429.0	1,381.5
Maximum Ht. of Dam	feet	25.0	26.9	29.0	21.0	21.5	25.5	27.0	37.5
Emergency Spillway									
Crest Elevation	feet	1,392.5	1,394.0	1,402.5	1,398.0	1,414.5	1,422.0	1,423.5	1,376.0
Bottom Width	feet	30	30	30	30	30	30	30	30
Type		Vegetated							
Percent Chance of Use		4	4	4	4	4	4	4	4
Ave. Curve No. - Cond. II		80	80	79	79	80	79	79	75
Emergency Spillway Hydrograph									
Storm Rainfall	inch	5.23	5.23	5.23	5.23	5.23	5.23	5.23	5.28
Storm Runoff	inch	3.10	3.10	3.01	3.01	3.10	3.01	3.01	2.67
Velocity of Flow (Vc)	ft./sec.	-	-	-	-	-	-	-	-
Discharge Rate	c.f.s.	-	-	-	-	-	-	-	-
Maximum w.s. Elevation	feet	-	-	-	-	-	-	-	-
Freeboard Hydrograph									
Storm Rainfall	inch	7.73	7.73	7.73	7.73	7.73	7.73	7.73	7.78
Storm Runoff	inch	5.37	5.37	5.26	5.26	5.37	5.26	5.26	4.84
Velocity of Flow (Vc)	ft./sec.	4.6	4.6	4.5	4.4	4.6	5.5	5.6	6.3
Discharge Rate	c.f.s.	92	98	88	90	96	170	180	265
Maximum w.s. Elevation	feet	1,394.0	1,395.5	1,403.9	1,399.4	1,416.0	1,424.0	1,425.6	1,378.5
Principal Spillway									
Capacity - Maximum	c.f.s.	6	10	5	7	6	28	20	34
Capacity Equivalents									
Sediment Volume	inch	1.14	1.34	1.39	0.99	1.31	1.35	1.30	2.00
Detention Volume	inch	3.40	3.57	3.29	3.52	3.40	3.45	3.29	2.95
Spillway Storage	inch	5.45	5.27	6.08	5.74	6.10	4.56	5.03	3.59
Class of Structure		a	a	a	a	a	a	a	a

1/ Crest of emergency spillway.

Table 3 Continued

Item	Unit	Structure Number							
		18-A	18-B	20-A	20-B	20-C	21-A	21-B	21-D
Drainage Area	sq. mi.	1.51	11.39	1.74	1.11	1.45	1.80	5.53	2.82
Storage Capacity									
Sediment	ac. ft.	163	1,032	155	102	100	167	419	262
Floodwater	ac. ft.	239	1,768	266	189	237	313	882	488
Total	ac. ft.	402	2,800	421	291	337	480	1,301	750
Surface Area									
Sediment Pool	acre	15.4	96.0	18.0	13.2	12.3	23.5	53.0	28.5
Floodwater Pool 1/	acre	37.4	230.0	42.5	31.5	35.0	58.5	142.0	74.0
Volume of Fill	cu. yds.	62,600	154,800	68,400	66,200	57,300	65,600	122,200	57,600
Elev. Top of Dam	feet	1,308.0	1,303.5	1,275.5	1,273.0	1,266.5	1,304.5	1,310.5	1,291.5
Maximum Ht. of Dam	feet	42.0	49.5	41.5	36.0	37.2	33.7	41.5	44.5
Emergency Spillway									
Crest Elevation	feet	1,302.5	1,298.0	1,270.0	1,267.5	1,261.0	1,299.0	1,305.0	1,286.0
Bottom Width	feet	30	245	30	30	36	30	30	30
Type	- - - - - - - - - - - - - Vegetated - - - - - - - - - - - - -								
Percent Chance of Use		4	4	4	4	4	4	4	4
Ave. Curve No. - Cond. II		76	76	75	78	77	77	77	78
Emergency Spillway Hydrograph									
Storm Rainfall	inch	5.28	7.78	5.28	5.28	7.78	5.28	5.28	5.28
Storm Runoff	inch	2.76	4.96	2.67	2.96	5.07	2.85	2.85	2.96
Velocity of Flow (Vc)	ft./sec.	-	6.6	-	-	5.0	-	-	-
Discharge Rate	c.f.s.	-	2,160	-	-	170	-	-	-
Maximum w.s. Elevation	feet	-	1,300.7	-	-	1,262.7	-	-	-
Freeboard Hydrograph									
Storm Rainfall	inch	7.78	13.45	7.78	7.78	13.45	7.78	7.78	7.78
Storm Runoff	inch	4.96	10.29	4.84	5.20	10.42	5.07	5.07	5.20
Velocity of Flow (Vc)	ft./sec.	6.4	10.0	6.4	5.8	9.9	5.8	7.3	6.6
Discharge Rate	c.f.s.	280	7,600	280	205	1,400	200	440	305
Maximum w.s. Elevation	feet	1,305.1	1,303.5	1,272.6	1,269.7	1,266.4	1,301.2	1,308.2	1,288.7
Principal Spillway									
Capacity - Maximum	c.f.s.	19	144	22	14	18	23	69	32
Capacity Equivalents									
Sediment Volume	inch	2.02	1.70	1.66	1.73	1.29	1.73	1.42	1.74
Detention Volume	inch	2.97	2.91	2.86	3.19	3.07	3.24	2.99	3.25
Spillway Storage	inch	3.14	2.30	3.05	3.63	2.94	4.00	3.36	3.15
Class of Structure		a	a	a	a	a	a	a	a

1/ Crest of emergency spillway.

Table 3 Continued

Item	Unit	Structure Number 23-B	23-C	23-D	25-C	27-C	27-D	Total
Drainage Area	sq. mi.	3.53	0.72	1.91	9.25	11.06	3.70	100.58
Storage Capacity								
Sediment	ac. ft.	211	49	133	774	495	270	7,934
Floodwater	ac. ft.	647	123	327	1,476	1,252	628	16,285
Total	ac. ft.	858	172	460	2,250	1,747	898	24,219
Surface Area								
Sediment Pool	acre	43.0	11.5	24.7	103.0	84.5	57.0	1,163.0
Floodwater Pool 1/	acre	107.0	24.5	67.5	233.0	197.0	123.0	2,750.7
Volume of Fill	cu. yds	69,500	42,000	60,700	134,100	113,600	73,400	2,554,900
Elev. Top of Dam	feet	1,336.0	1,334.0	1,339.5	1,311.5	1,344.5	1,385.5	xx
Maximum Ht. of Dam	feet	28.8	26.0	32.5	37.0	35.5	26.0	xx
Emergency Spillway								
Crest Elevation	feet	1,330.5	1,328.5	1,334.0	1,306.0	1,339.0	1,380.0	xx
Bottom Width	feet	30	30	30	200	200	70	xx
Type	- - - - - - - - - - - - - Vegetated - - - - - - - - - - - - -							
Percent Chance of Use		4	4	4	4	4	4	xx
Ave. Curve No. - Cond. II		79	78	77	75	78	78	xx
Emergency Spillway Hydrograph								
Storm Rainfall	inch	5.28	5.28	5.28	7.78	7.73	7.73	xx
Storm Runoff	inch	3.05	2.96	2.85	4.79	5.15	5.15	xx
Velocity of Flow (Vc)	ft./sec.	-	-	-	5.8	5.7	5.7	xx
Discharge Rate	c.f.s.	-	-	-	1,240	1,300	440	xx
Maximum w.s. Elevation	feet	-	-	-	1,308.2	1,341.1	1,382.1	xx
Freeboard Hydrograph								
Storm Rainfall	inch	7.78	7.78	7.78	13.45	13.40	13.40	xx
Storm Runoff	inch	5.30	5.20	5.07	10.09	10.53	10.53	xx
Velocity of Flow (Vc)	ft./sec.	6.4	5.0	5.4	10.0	9.9	9.9	xx
Discharge Rate	c.f.s.	280	125	178	6,600	6,550	2,470	xx
Maximum w.s. Elevation	feet	1,333.1	1,330.2	1,336.0	1,311.5	1,344.4	1,385.4	xx
Principal Spillway								
Capacity - Maximum	c.f.s.	42	9	22	128	138	39	xx
Capacity Equivalents								
Sediment Volume	inch	1.12	1.27	1.31	1.57	1.26	1.37	xx
Detention Volume	inch	3.43	3.19	3.22	3.00	3.19	3.19	xx
Spillway Storage	inch	3.97	4.70	4.63	3.75	3.20	4.22	xx
Class of Structure		a	a	a	a	a	a	xx

1/ Crest of emergency spillway.

TABLE 3A - STRUCTURE DATA
GRADE STABILIZATION STRUCTURES

Upper Big Nemaha Watershed, Nebraska

Site Number	Drainage Area (Acres)	Surface Area at Crest of Riser (Acres)	Surface Area at Emergency Spillway (Acres)	Drop (Feet)	Earth Fill (Cu. Yds.)	Type of Structure
G-2	550	9.6	16.7	25.0	26,800	Drop Inlet
G-5	145	Top of Bank	.1	8.0	500	Drop Inlet
G-8	100	2.0	2.9	14.0	8,200	Drop Inlet
G-12	211	5.1	7.7	13.5	14,800	Drop Inlet
G-12A	129	3.3	5.0	11.0	11,700	Drop Inlet
G-13	346	3.5	6.8	10.0	14,600	Drop Inlet
G-14	149	3.5	5.5	20.5	8,600	Drop Inlet
G-15	87	1.9	3.4	20.5	12,200	Drop Inlet
G-16	252	Less than 0.1	2.4	6.0	1,000	Drop Spillway
G-16A	433	8.1	13.8	22.5	38,000	Drop Inlet
G-18	404	.7	3.1	6.0	1,000	Drop Spillway
G-18A	651	14.4	25.2	17.0	28,900	Drop Inlet
G-19	421	8.9	14.2	20.0	26,200	Drop Inlet
G-20	145	2.6	3.8	23.5	12,200	Drop Inlet
G-22	184	1.6	5.6	10.5	14,600	Drop Inlet
G-23	132	3.3	5.0	19.0	15,300	Drop Inlet
G-24	403	10.3	16.3	21.0	22,800	Drop Inlet
G-25	432	9.7	14.4	18.0	28,000	Drop Inlet
G-27	394	7.8	12.8	19.5	27,900	Drop Inlet
G-29	168	3.7	5.5	16.5	17,800	Drop Inlet
G-31	174	3.3	6.3	29.5	29,800	Drop Inlet
G-32	182	3.5	6.0	23.0	15,100	Drop Inlet
G-33	335	9.3	14.3	14.5	18,600	Drop Inlet
G-34	193	4.2	7.3	14.5	16,200	Drop Inlet
G-35	547	11.0	21.5	16.0	18,900	Drop Inlet
G-37	138	2.7	5.3	16.5	15,600	Drop Inlet

Table 3A Continued

Site Number	Drainage Area (Acres)	Surface Area at Crest of Riser (Acres)	Surface Area at Emergency Spillway (Acres)	Drop (Feet)	Earth Fill (Cu. Yds.)	Type of Structure
J-4	200	.1	.3	10.0	1,000	Drop Spillway
J-5	206	.1	.3	12.5	2,000	Drop Inlet
J-11	248	2.7	7.3	13.0	16,300	Drop Inlet
J-12	792	13.0	22.0	28.0	44,800	Drop Inlet
J-12A	480	7.8	14.2	18.5	20,700	Drop Inlet
J-15	160	2.4	5.7	21.0	11,000	Drop Inlet
J-15A	242	3.2	7.3	15.0	12,800	Drop Inlet
J-22	191	.2	1.2	10.0	3,600	Drop Inlet
J-24	154	.2	.5	8.5	8,000	Drop Inlet
J-27	172	2.5	5.2	18.5	18,500	Drop Inlet
J-28	153	2.7	4.7	27.0	21,500	Drop Inlet
J-32	112	1.7	2.9	27.0	11,800	Drop Inlet
J-34	163	3.0	5.6	16.5	8,600	Drop Inlet
J-36	438	7.2	13.4	18.5	26,500	Drop Inlet
J-37	418	7.7	14.8	15.5	21,800	Drop Inlet
J-40	169	2.9	5.3	18.0	10,800	Drop Inlet
J-41	1,759	13.8	39.4	23.5	46,600	Drop Inlet
J-42	628	8.3	15.2	16.0	20,400	Drop Inlet
J-44	351	6.0	10.5	20.5	27,900	Drop Inlet
J-45	226	4.0	6.1	18.0	11,100	Drop Inlet
O-1	191	3.7	6.5	18.0	12,900	Drop Inlet
L-3	431	.1	1.2	6.0	1,000	Drop Spillway
L-3A	226	4.6	10.1	7.0	8,400	Drop Inlet
L-4	660	14.0	27.9	15.0	31,000	Drop Inlet
L-5	144	3.5	6.3	9.5	8,100	Drop Inlet
L-7	177	4.4	8.0	17.0	15,400	Drop Inlet
L-8	113	2.6	4.5	12.0	9,900	Drop Inlet
L-9	252	6.5	9.9	13.5	14,200	Drop Inlet

Table 3A Continued

Site Number	Drainage Area (Acres)	Surface Area at Crest of Risers (Acres)	Surface Area at Emergency Spillway (Acres)	Drop (Feet)	Earth Fill (Cu. Yds.)	Type of Structure
L-10	292	6.9	12.2	15.5	20,400	Drop Inlet
L-12	485	8.7	15.5	13.5	14,500	Drop Inlet
L-15	133	2.7	6.0	15.5	11,100	Drop Inlet
L-16	476	12.0	20.5	17.5	37,200	Drop Inlet
L-17	163	4.7	7.9	15.5	14,100	Drop Inlet

February, 1965

TABLE 4 - ANNUAL COSTS

Upper Big Nemaha Watershed, Nebraska

(Dollars)

Evaluation Unit	Amortization of Installation Costs 1/	Operation and Maintenance 2/	Total
Structural Measures Floodwater Retarding Structures (38) and grade stabilization structures (59)	139,820	6,790	146,610
Total	139,820	6,790 3/	146,610

1/ 1964 construction costs, amortized at 3 1/8 percent for 50 years.
2/ Long-term projected prices, .3 percent of construction costs.
3/ $2,720 - Cash cost to sponsoring local organizations.
$4,070 - Value of goods and services contributed by owners and operators of land upon whose property the works of improvement are located and the individual directors of the Upper Big Nemaha Watershed Conservancy District.

February, 1965

TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

Upper Big Nemaha Watershed, Nebraska

(Dollars) 1/

Item	Estimated Average Annual Damage		Damage Reduction Benefit
	Without Project	With Project	
Floodwater			
Crop and Pasture	190,110	62,950	127,160
Other Agricultural	28,520	9,440	19,080
Nonagricultural			
Road and Bridge	54,110	13,850	40,260
Railroad	1,660	80	1,580
Urban	6,860	1,410	5,450
Subtotal	281,260	87,730	193,530
Erosion			
Floodplain Scour	8,980	3,650	5,330
Gullies	46,370	0 2/	46,370
Subtotal	55,350	3,650	51,700
Sediment			
Sediment Deposition	600	100	500
Indirect	35,300	10,620	24,680
Total	372,510	102,100	270,410

1/ Price base, long-term projected.
2/ This includes the evaluated area only.

February, 1965

TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES
Upper Big Nemaha Watershed, Nebraska
(Dollars) 1/

Evaluation Unit	Average Annual Benefits: Flood Prevention: Damage Reduction	Average Annual Benefits: Flood Prevention: Changed Land Use	Average Annual Benefits: Flood Prevention: More Intensive Use	Average Annual Benefits: Secondary	Average Annual Benefits: Total	Average Annual Cost	Benefit Cost Ratio
Structural Measures Floodwater Retarding Structures (38) and Grade Stabilization Structures (59)	227,080	2,400	130	16,340	245,950	146,610	1.7:1
Total	227,080 2/	2,400	130	16,340	245,950	146,610	1.7:1

1/ Price base - Benefits are long-term projected. Costs, see Table 4, Footnotes 1 and 2.
2/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefits of $43,330 annually.

February, 1965

INVESTIGATIONS AND ANALYSES

Land Treatment Investigations

Available soil survey maps were measured. Tabulation of soil mapping units, slopes, erosion and classification of land unit capabilities were made to determine present and future land uses, conservation treatment measures, and hydrologic condition of the vegetative cover.

The Work Unit personnel and the State District Extension Forester provided the data necessary to prepare the conservation needs analysis for Tables 1 and 1A. This consisted of such items as practices to be used, unit cost, technical assistance time, those amounts of measures required for total needs, amounts applied to date and during project installation and an analysis of basic and revised plans.

Hydraulic and Hydrologic Investigations

Hydraulic and hydrologic investigations were made primarily to determine runoff characteristics which are expected to take place before and after the conditions of this plan have been fulfilled.

Since there are no measured stream flows in this watershed, surface runoff is based upon procedures described in the Hydrology Handbook, Supplement A. This method considers three variables: rainfall, antecedent moisture condition, and the hydrologic soil-cover complex.

Rainfall was based upon precipitation amounts as published in United States Weather Bureau Technical Paper Number 40 and other Weather Bureau published data (Beatrice and Lincoln Stations). A partial-duration synthetic-storm series was developed based upon three damaging storms per year.

Hydrologic soil-cover complex numbers show the effect soil type, land use, and land treatment have on runoff. An average antecedent moisture condition was used.

The watershed was divided into 40 areas to compute soil-cover complex numbers. The weighted average for present conditions is 79. With the proposed land treatment measures applied, the average is 77. The inventory of soil and land uses, from soil survey maps and estimates of conservation applied and to be applied during the project period, were used in making the analysis.

The watershed was divided into 115 sub-watershed areas. Unit hydrographs were developed for each sub-watershed based on storms typical of the area.

Area inundated by depth increments was based on 44 cross sections. The relationship of acres inundated to discharge rates was based on a synthetic storm series.

Relation of volume runoff to discharge was developed by floodrouting using Wilson's method. Floodrouting determined the discharge for the unit volume of runoff for each cross section.

The following conditions were evaluated:

1. Current watershed conditions.
2. Watershed conditions with project land treatment applied.
3. Watershed conditions with project land treatment and floodwater retarding structures installed. Several structural systems were studied.

Storage requirements were based on Technical Release Number 10.

Floodwater retarding structure release rates were established considering downstream channel capacities and economics of floodwater storage. Individual structure release rates are shown on Table 3.

Emergency spillways' dimensions were determined by floodrouting the emergency spillway and the freeboard hydrographs by the method outlined in Lincoln E&WP Unit Hydrologic Procedure Number 2. Emergency spillways will meet minimum criteria, as established by the State of Nebraska.

Geologic Investigations

This watershed has wide exposures of Kansas glacial till. The higher hills and uplands have thin caps of Peorian and Loveland loess. Limestones and shales of Permian age underlie the area at depth and are not exposed in the watershed.

Till consists of fine sandy silt and some boulders, cobbles, and gravels. Within the till are beds and pockets of fine sand ranging up to thirty feet thick.

Preliminary geologic investigations were made of all proposed structure sites by the use of a truck-mounted drilling rig, a hand auger and/or observations. Information was obtained from these investigations to estimate seepage problems, availability of borrow material, location of emergency spillways, and other factors that would appreciably affect cost of structures or indicate hazards.

Geologic conditions of each floodwater retarding structure are described on forms SCS-375, "Preliminary Geologic Investigations of Dam Sites." A summary report of expected geologic conditions of grade stabilization structures is also on file. Detailed investigations and laboratory testing will be accomplished prior to construction of structures.

The geologic formations in general are:

Peorian Loess	-	Pleistocene System
Loveland Loess	-	Pleistocene System
Kansas Glacial Till	-	Pleistocene System
Chase Group	-	Permian System
Council Grove Group	-	Permian System

Floodplain Damage Investigations

A detailed investigation of floodplain damages was made by using a hand probe and making observations along or near each hydrologic cross section. The

damages mapped were expanded the distance represented by that cross section. Percent damage per depth of scour or deposits was based on recommendations of the State Conservation Agronomist.

Damage reduction for floodplain scour was based on decreased depth of flooding reduction. Sediment damage reduction was based on the reduced area and frequency flooded and the reduction of available sediment.

Sedimentation Investigations

Sediment-storage requirements for floodwater retarding structures were calculated by using the Musgrave formula in accordance with Engineering Memorandum, Nebraska No. 9. Soil classifications were taken from soils maps. Land slopes, length of slope, and present land use were obtained by field surveys. Estimates of future land use were based on the conservation needs study.

Principal spillway elevations on drop inlet type grade stabilization structures are located to protect overfalls and/or to furnish a stable outlet for land treatment measures. In most instances, a sediment-storage area is created that exceeds that needed for a 25-year sediment pool. Allowances were made, however, for sediment storage within the flood pool equaling 25 percent of 25 years expected sediment.

Grade Stabilization Investigations

Future damages from unstable grade problem areas were based on past damages evidenced by comparing aerial photographs of differing dates and by landowner-operator interviews. These damages include land void and depreciation; changed land use due to inaccessibility or units broken into areas too small to economically crop; road, bridge, and fence damages; and other damages that can be predicted from increased growth of these gullied areas.

One hundred and two land stabilization problem areas were investigated to determine the seriousness of the problem and to explore their physical and cultural limitations.

Economic Investigations

Determination of Damages

Interviews with local farmers and Soil Conservation Service technicians familiar with the watershed form the basic data used in the evaluation of agricultural damages. About 60 percent of the total problem area was covered by these interviews. Publications of other agencies pertaining to crop yields, acreages, costs, and prices of agricultural products supplemented this information. Estimates of normal flood-free crop yields were adjusted to allow for expected yield increases resulting from advances in technology. The adjustments were based on the assumption that management and production practices now used by the better farmers would be in general use over the life of the project. The following table shows the present cropping pattern, typical adjusted yields and the composite gross value per acre of Upper Big Nemaha floodplain.

Gross Value of Composite Floodplain Acre (Cropland)

Crop	Flood-Free Yield	Long-Term Projected Prices	Percent Distribution	Gross Value
Corn	65 Bu.	$ 1.39	50	$45.18
Milo	70 Bu.	1.25	30	26.25
Wheat	30 Bu.	1.60	10	4.80
Alfalfa	4.5 Ton	16.10	7	5.07
Soybeans	30 Bu.	2.25	3	2.02
Total			100	$83.32

The 100-year synthetic series method was used in evaluating floodwater damage to crops and pastures. Area inundated by the various frequency storms was derived from stage-area inundated curves. The crop damage rate was determined as the value of reduced crop yields and adjusted to allow for any increase or decrease of production expenses. These damage rates were computed for various depths of inundation by months, then weighted by the percent of excessive storms that occur in each month. The weighted rates were multiplied by acreages inundated by selected discharges. A dollar damage versus discharge curve was developed to provide a monetary value for each storm in the 100-year storm series.

Other agricultural damage (such as floodwater damage to fences, farm buildings, livestock, and clean-up of debris) was determined from an analysis of damage schedules furnished by the conservancy district. About 5 percent of these schedules were checked for reliability. These other agricultural damages were estimated to be 15 percent of crop and pasture damage.

Data used in the evaluation of roads and bridges were obtained from county road officials. Annual damage to bridges in close proximity to structures was evaluated by comparing replacement costs and length of life with and without the project. The effectiveness of the structures will allow this reduction without increasing the hazard of future floods. Dollar damage versus discharge curves were developed for bridges located further downstream. Estimated benefits to these bridges will accrue from a reduced maintenance cost. Damage to roads was related to length of road flooded and the estimated replacement costs for road fill and gravel.

Basic data on present railroad damages were formed from interviews with railroad officials during work plan investigations of other watersheds. Damage estimates by discharge rates stemmed from length of track flooded by depth increments.

An analysis of urban damages was made from historical storm data. This study combined the use of local interviews and the damage interview schedules provided by the sponsoring organization and relating same to a storm frequency-discharge basis. Stage damage curves were developed to cover the range of damage-producing floods.

The estimated monetary value of the physical damage to the floodplain from erosion and sediment deposition was based on the value of the production lost, taking into account the lag in recovery of productivity and the cost of farm operation to speed recovery. Damage was related to depth of flooding, with weight given to increased velocity from deeper flows.

Damage from gully erosion was based on production lost when land is voided or depreciated. The physical land damages in an average annual rate were multiplied by the monetary values of such damage.

Two methods were used to determine these monetary values per unit of damage. The method as outlined in Chapter V, Economics Guide, was used for the voided conditions and those areas depreciated at a high degree.

A second method was used in areas not subject to voiding or extremely high depreciation to determine the values of the loss of production resulting from the absence of land treatment. Technical guides for Johnson County, Gage County, Lancaster and Otoe Soil and Water Conservation Districts require that a grassed waterway or outlet channel be established for all gradient terraces and that the area between terrace ridges be contour farmed. The guides require a stable outlet as a prerequisite to establishment of grassed waterways. Interviews with local Soil Conservation Service technicians and SWCD supervisors and field investigations reveal that in many areas of the watershed terraces and stable grassed waterways cannot be installed because of unstable conditions. Production losses in these areas will result from deterioration of land resources over time and after proper discounting, have been included as damages. Additional monetary damages were also assigned to other types of property such as roads, bridges, fences and livestock water wells.

Indirect damages were estimated at 10 percent of the agricultural damages and 20 percent of the nonagricultural damages. This damage includes interruption of and extra travel due to road damage; interruption of public utility services; inconveniences and hardships in repairing and replacing equipment, supplies, and materials damaged by floods; and loss of business income.

Benefits from Reduction of Damages

Average annual damages were calculated for conditions without a project, with land treatment installed, and after installation of the complete project. The difference between the damages at the time of initiation of each project increment and that expected after its installation constitutes the damage reduction benefits brought about by that increment.

Benefits from reduction of crop and pasture, other agricultural, railroad, and urban damages resulted from the combined effect of reduction in area inundated and reduced depth of inundation.

The reduction of upland land damage caused by the absence of land treatment was measured as the difference in net income under improved management as opposed to net income without land treatment. For each type of management all production and overhead costs were deducted to calculate net income. Crop yield information was obtained on bench mark soils from Standard Soil Survey data.

Land treatment installation and maintenance costs were determined by analyzing the watershed conservation needs information. These costs were converted to an annual figure at a six percent rate of interest and deducted as associated costs.

The annual net damage per acre was applied to portions of each drainage area where adequate land treatment measures could not be installed and/or maintained.

Appropriate discounting at a 3 1/8 percent rate was applied to areas that are now treated but will be affected in future years. Portions of the drainage areas above certain road structures (corrugated metal or concrete tubes or boxes) and existing Public Law 46 structures were not included.

Changed Land and More Intensive Use Benefits

Farmers in the floodplain were asked what changes in land use might be expected if floods were reduced in extent and frequency. Their responses indicated that some floodplain areas, now in woody pasture, will be cleared and farmed more intensively after the hazards of flooding are reduced. In other areas, more intensive use will take place with the improvement of tame pastures. These local responses were correlated with soil productivity, floodplain topography, accessibility with modern farm machinery and other pertinent factors. Areas to be cleared are in evaluation reaches where project installation has reduced flooding to a four-year frequency or less and/or reduced the acres inundated at a four-year frequency storm event by more than 50 percent. The benefits per acre reflect the estimated change in net income, less development costs and damages of higher value use. Benefits were discounted five years following project installation to reflect a lag in time for benefits to accrue. Development costs were amortized at a six percent rate of interest over a 50-year period.

Secondary Benefits

Secondary benefits to structural measures were computed in accordance with Watersheds Memorandum SCS-57. The value of local secondary benefits stemming from the project was considered to be 10 percent of the direct primary benefits. These benefits, which accrue within the immediate zone of influence of the project, are from the transporting, processing, and marketing of those goods and services that produce the primary structural benefits. No induced secondary benefits were claimed.

Appraisal of Land and Easement Values

Cost per acre of land, easements, and rights-of-way reflects the sponsors' estimates. Landlord's net return was analyzed and the resulting value was capitalized. Records showing recent land sales were also studied. These compared favorably to the sponsors' estimate. Cost per acre of areas encroached on by structure sites and sediment pools was considered to be 100 percent of the estimated market value. Cost of necessary easements for flood storage was considered to be 50 percent of the estimate.

Price Base

Long-term prices, as projected by ARS and AMS, were used for benefit determinations. These prices are from "Agricultural Price and Cost Projections,"

dated September, 1957. Cost of land treatment measures, technical assistance, and structural works of improvement are estimated at 1964 price levels. Installation costs were amortized at three and one-eighth percent interest for 50 years.

Operation and Maintenance

Operation and maintenance cost for floodwater and grade stabilization structures was estimated at .3 percent of construction cost.

Details of Methodology

Details of the procedures used in the evaluation are described in the Soil Conservation Service Economics Guide for Watershed Protection and Flood Prevention, March, 1964.

Engineering Investigations

Preliminary designs and cost estimates were made for the floodwater retarding and grade stabilization structures. Cross sections, profiles, and topography are based on sea level datum.

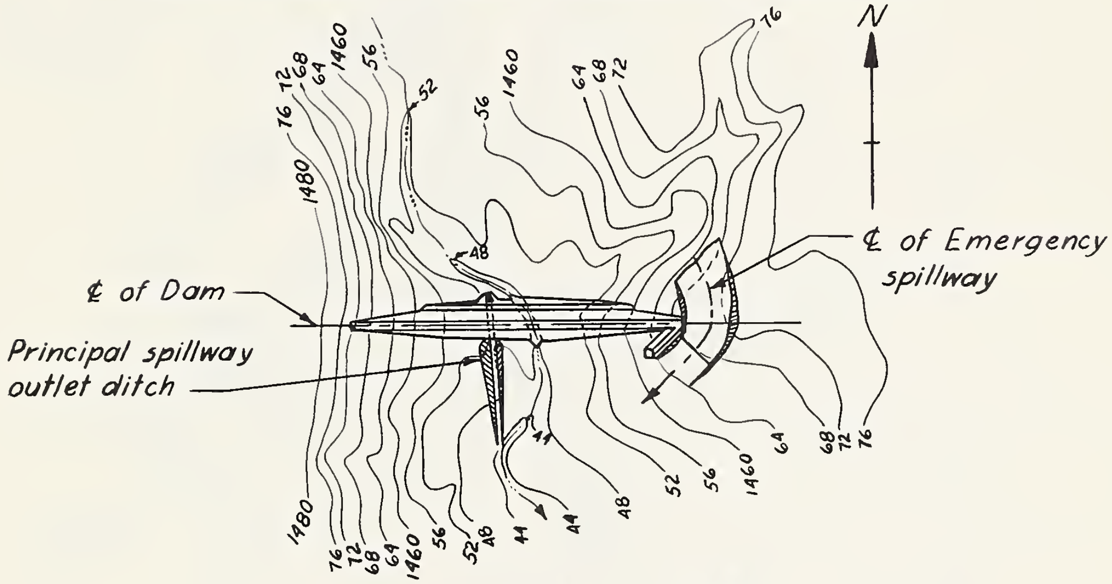
Storage volume includes capacity for submerged sediments below the principal spillway elevation.

Design velocity of the emergency spillways is based upon the erosive characteristics of the soil at the site. Structural classification and design of the principal and emergency spillways are based upon criteria established in Washington Engineering Memorandum 27, dated March 14, 1958. Amounts of rainfall from Atlases derived from U. S. Weather Bureau Technical Paper No. 40 were used in the routing of the emergency spillways. The emergency spillways' size exceeds requirements established in Washington Engineering Memorandum No. 31, Rev. April 2, 1959.

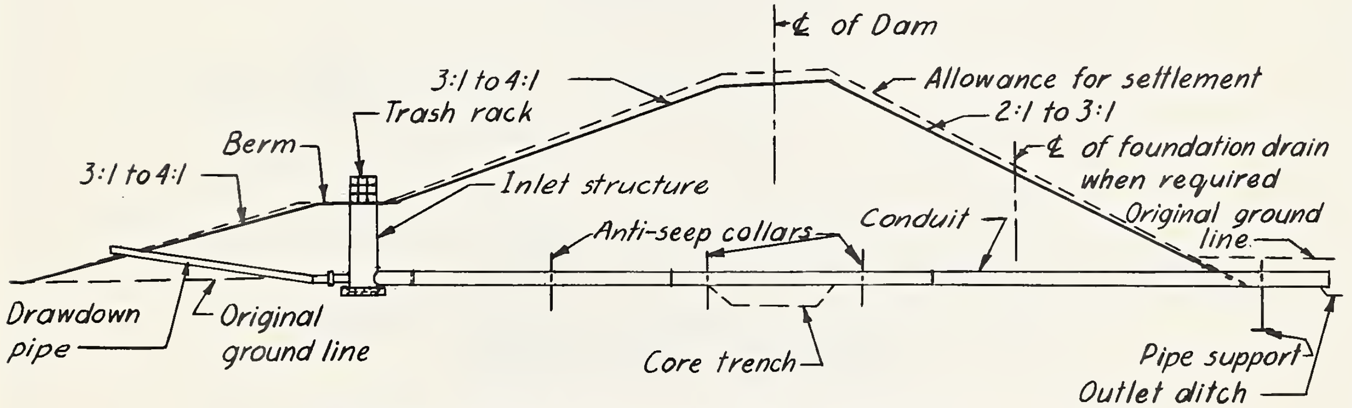
The emergency spillways have been enlarged over standard design criteria for grade stabilization structures in series with other grade stabilization structures and above floodwater retarding structures.

Land rights work maps were prepared and reviewed with the watershed conservancy district board and those landowners involved. These maps were revised into final form in accordance with NB-2204.13, Watershed Protection Handbook, and placed in the base files.

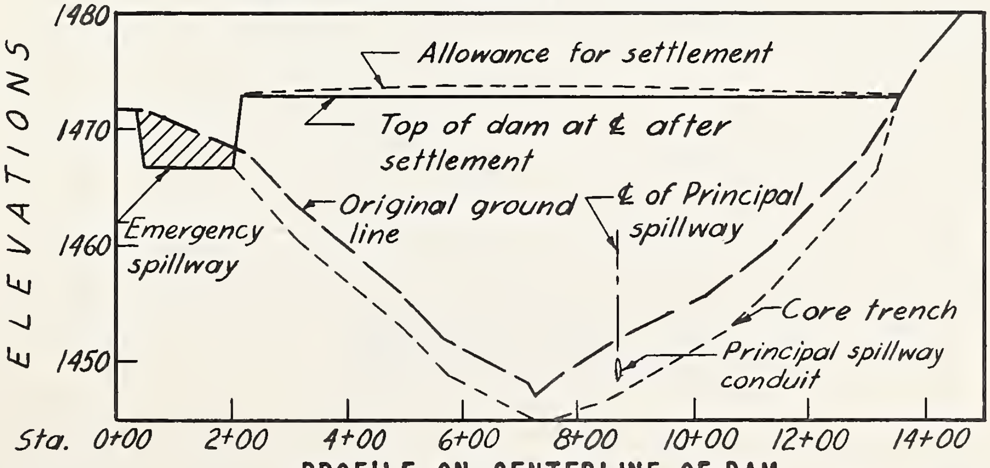
TYPICAL FLOODWATER RETARDING STRUCTURE WITH SINGLE STAGE PRINCIPAL SPILLWAY



GENERAL PLAN



CROSS SECTION OF DAM ON CENTERLINE OF SINGLE STAGE PRINCIPAL SPILLWAY



PROFILE ON CENTERLINE OF DAM

Figure 1

USDA-SCS

Rev. 2-64 5,L-15,520

TYPICAL STABILIZING AND SEDIMENT CONTROL STRUCTURE

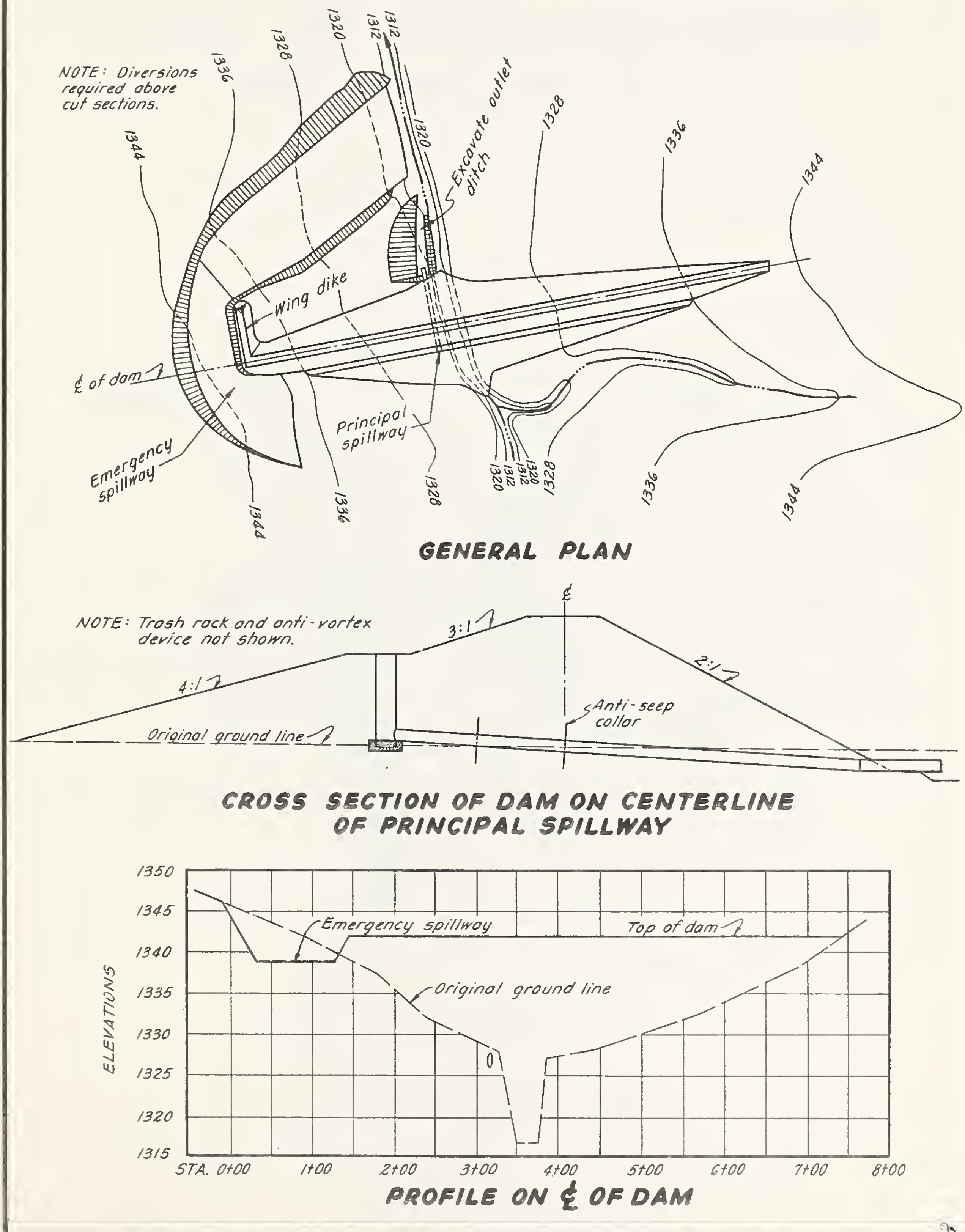


Figure 2

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

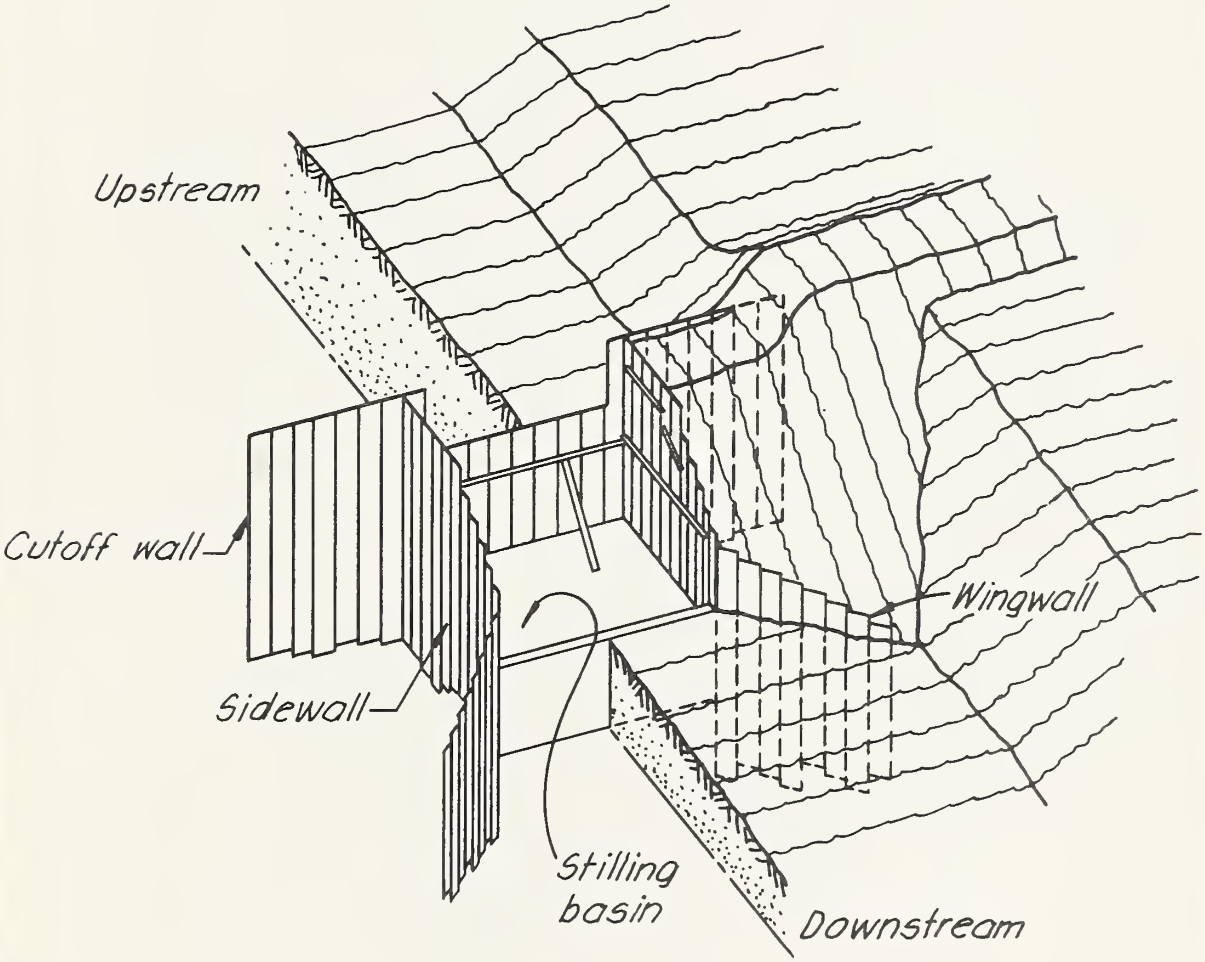
USDA-SCS-LINCOLN, NEBR. 1964

5, L-20,426

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

TYPICAL GRADE STABILIZATION STRUCTURE

SHEET PILING DROP SPILLWAY



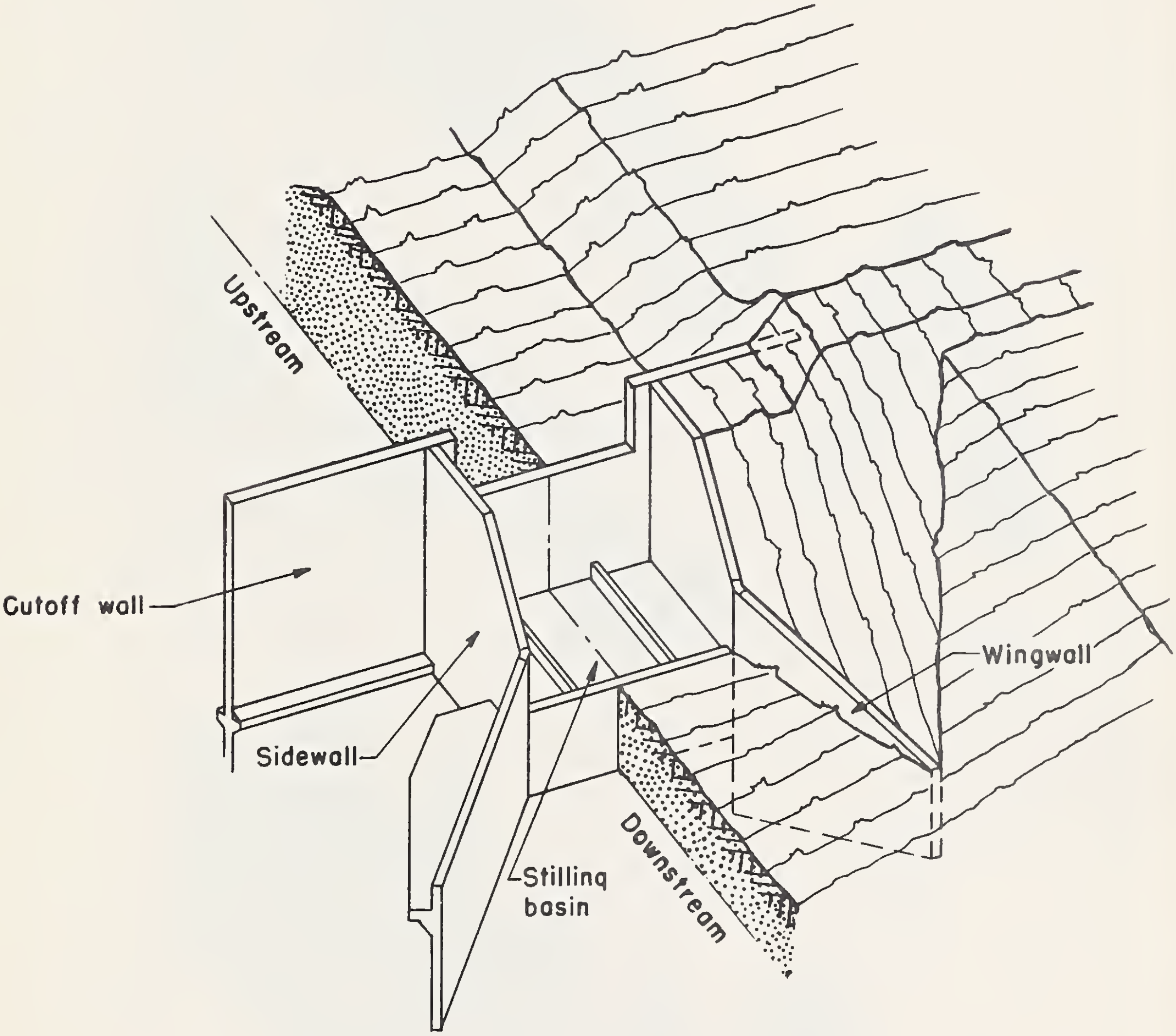
PERSPECTIVE VIEW

Figure 3

USDA SCS LINCOLN NEBR 1963

5,L-19,677

TYPICAL GRADE STABILIZATION STRUCTURE
CONCRETE DROP SPILLWAY

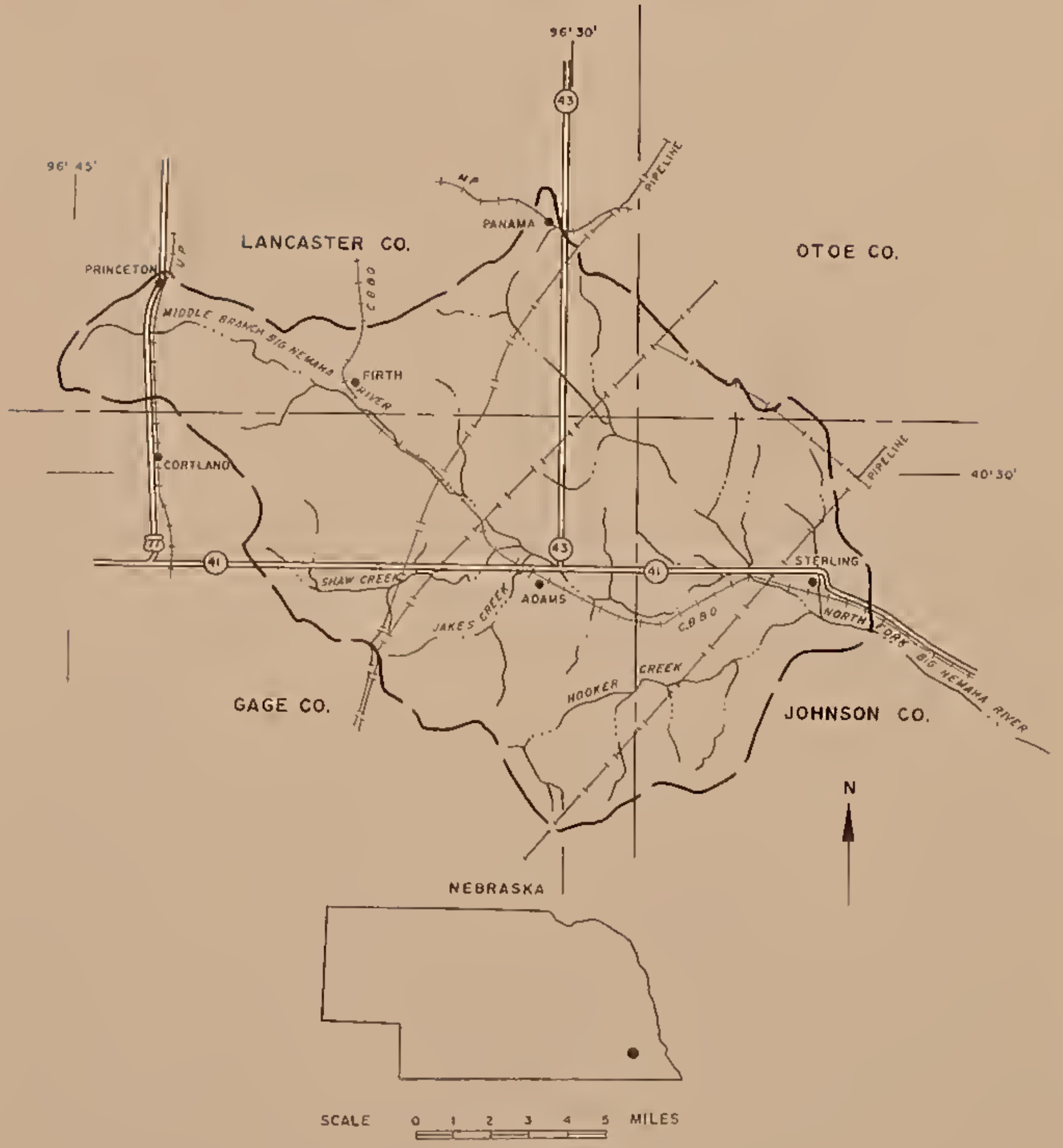


PERSPECTIVE VIEW

Figure 4

PROJECT LOCATION MAP

UPPER BIG NEMAHA WATERSHED



U. S. DEPARTMENT OF AGRICULTURE

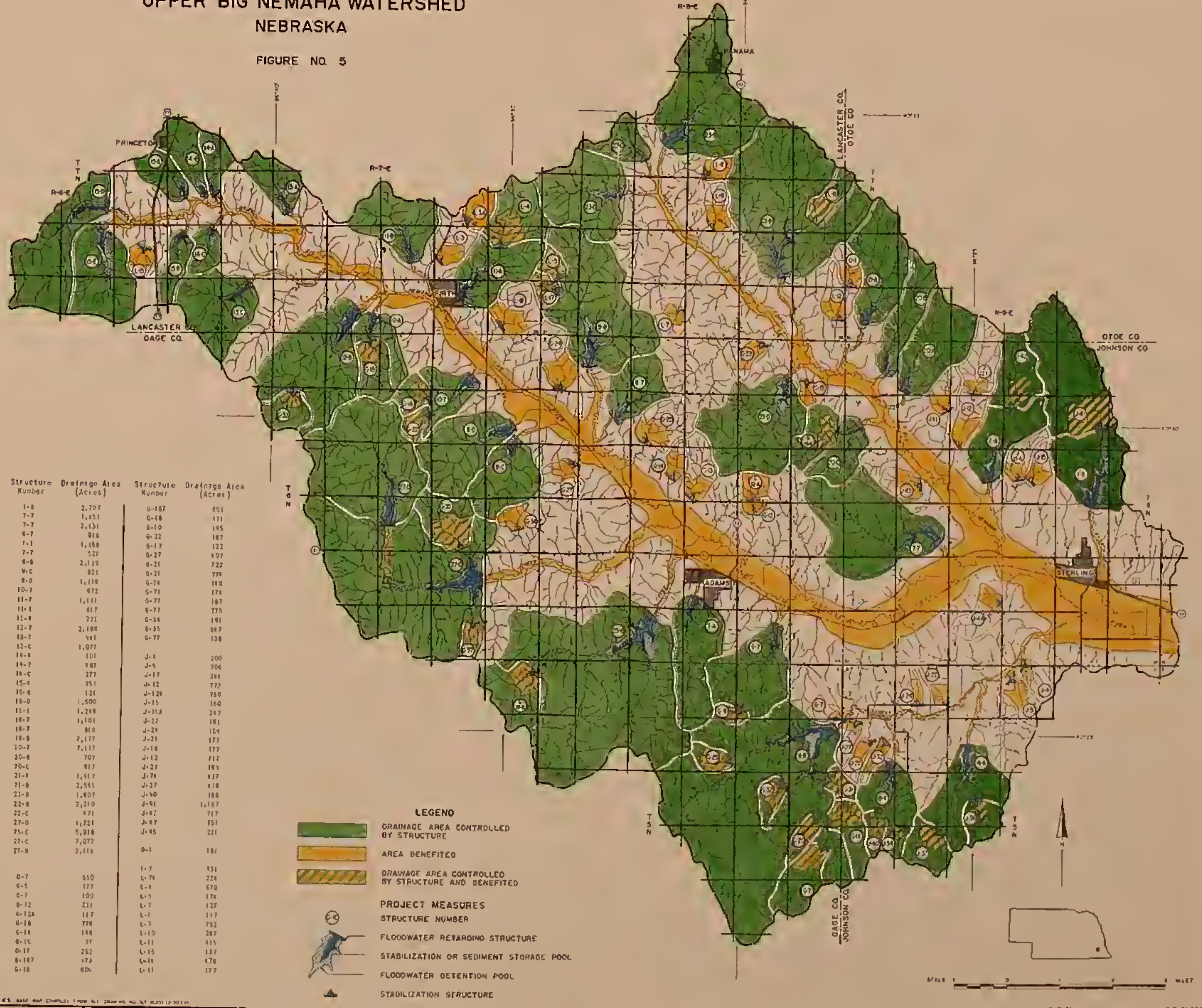
SOIL CONSERVATION SERVICE

PROJECT MAP

UPPER BIG NEMAHA WATERSHED

NEBRASKA

FIGURE NO. 5



Structure Number	Drainage Area (Acres)
1-8	2,707
7-7	1,451
7-7	2,151
0-7	816
F-1	1,168
7-7	527
8-8	2,139
9-C	821
8-0	1,118
10-7	472
11-7	1,111
11-1	417
11-8	771
12-7	2,188
13-7	481
12-C	1,077
14-8	101
14-7	487
14-C	277
15-8	751
15-8	121
18-0	1,500
11-1	1,248
18-7	1,101
18-7	810
18-8	7,177
20-7	7,117
20-8	707
20-C	817
21-8	1,517
21-8	2,545
21-0	1,407
22-8	7,210
22-C	471
27-0	1,721
25-C	5,018
27-C	7,077
27-8	2,118
0-7	550
0-5	177
0-7	100
0-12	211
G-12A	117
G-18	778
G-18	198
G-15	77
G-17	252
G-147	178
G-18	606

Structure Number	Drainage Area (Acres)
G-107	651
G-18	471
G-10	145
G-22	187
G-17	122
G-27	407
G-21	722
G-21	778
G-24	188
G-71	178
G-77	187
G-77	775
G-38	181
G-35	687
G-77	138
J-4	200
J-5	708
J-17	288
J-12	772
J-12A	758
J-15	160
J-15A	217
J-22	181
J-24	154
J-31	177
J-18	177
J-12	212
J-27	185
J-78	437
J-27	418
J-40	188
J-41	1,187
J-42	717
J-47	351
J-45	221
O-1	181
L-7	431
L-78	228
L-4	670
L-5	178
L-7	127
L-1	177
L-3	752
L-10	287
L-11	415
L-15	137
L-18	478
L-11	177

7-17-65

5,R-21,055